AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

S. HRG. 114–48

REGIONAL IMPACTS OF EPA CARBON REGULATIONS: THE CASE OF WEST VIRGINIA

FIELD HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED FOURTEENTH CONGRESS

FIRST SESSION

MARCH 23, 2015—BECKLEY, WV

Printed for the use of the Committee on Environment and Public Works

Available via the World Wide Web: http://www.gpo.gov/fdsys

REGIONAL IMPACTS OF EPA CARBON REGULATIONS: THE CASE OF WEST VIRGINIA

S. HRG. 114–48

REGIONAL IMPACTS OF EPA CARBON REGULATIONS: THE CASE OF WEST VIRGINIA

FIELD HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED FOURTEENTH CONGRESS

FIRST SESSION

MARCH 23, 2015—BECKLEY, WV

Printed for the use of the Committee on Environment and Public Works

Available via the World Wide Web: http://www.gpo.gov/fdsys

U.S. GOVERNMENT PUBLISHING OFFICE
94–986 PDF WASHINGTON : 2015

For sale by the Superintendent of Documents, U.S. Government Publishing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

ONE HUNDRED FOURTEENTH CONGRESS
FIRST SESSION

JAMES M. INHOFE, Oklahoma, *Chairman*

DAVID VITTER, Louisiana
JOHN BARRASSO, Wyoming
SHELLEY MOORE CAPITO, West Virginia
MIKE CRAPO, Idaho
JOHN BOOZMAN, Arkansas
JEFF SESSIONS, Alabama
ROGER WICKER, Mississippi
DEB FISCHER, Nebraska
MIKE ROUNDS, South Dakota
DAN SULLIVAN, Alaska

BARBARA BOXER, California
THOMAS R. CARPER, Delaware
BENJAMIN L. CARDIN, Maryland
BERNARD SANDERS, Vermont
SHELDON WHITEHOUSE, Rhode Island
JEFF MERKLEY, Oregon
KIRSTEN GILLIBRAND, New York
CORY A. BOOKER, New Jersey
EDWARD J. MARKEY, Massachusetts

RYAN JACKSON, *Majority Staff Director*
BETTINA POIRIER, *Democratic Staff Director*

CONTENTS

Page

MARCH 23, 2015

OPENING STATEMENT

Capito, Hon. Shelley Moore, U.S. Senator from the State of West Virginia 1

WITNESSES

Jenkins, Hon. Evan H., U.S. Representative from the State of West Virginia .. 4
Trisko, Eugene M., Attorney at Law, on behalf of the United Mine Workers of America 5
  Prepared statement 8
Patton, Charles, President and Chief Operating Officer, Appalachian Power Company 13
  Prepared statement 15
Richardson, L. Jeremy, Ph.D., Senior Energy Analyst for the Union of Concerned Scientists 41
  Prepared statement 43
Van Nostrand, James M., Associate Professor and Director of the Center for Energy and Sustainable Development, West Virginia University College of Law 87
  Prepared statement 90
Farmer, Chuck, President, Rouster Wire, Rope and Rigging 98
  Prepared statement 101

ADDITIONAL MATERIAL

Union of Concerned Scientists:
  Policy brief: Strengthening the EPA's Clean Power Plan 122
  Technical Comments on the Clean Power Plan 130
  Report: National Landmarks at Risk 255

REGIONAL IMPACTS OF EPA CARBON REGULATIONS: THE CASE OF WEST VIRGINIA

MONDAY, MARCH 23, 2015

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
Beckley, WV.

OPENING STATEMENT OF HON. SHELLEY MOORE CAPITO, U.S. SENATOR FROM THE STATE OF WEST VIRGINIA

Senator CAPITO. I want to thank Congressman Evan Jenkins for joining me here today. It's great to be in Raleigh County. I want to thank the Raleigh County Commission, the Sheriff's Office and Judge Kirkpatrick for letting us use your chambers. I want to thank all of you for coming. I want to thank the witnesses for being here today.

This is the first hearing that I've chaired as I've come back home as a United States Senator. But it will not be the last one, I can tell you that. This issue we have before us, which is the Greenhouse Gas Rule and the Clean Air Rule, falls right squarely in my subcommittee on the energy—or the Environment of Public Works Committee in the Senate. I'm going to be chairing that subcommittee. So all the data that we collect in our hearings is extremely valuable to us on the committee. And I want to thank everybody for their participation. But it's no more important to all the folks that live in and around West Virginia, particularly Southern West Virginia.

Last month, EPA acting administrator—assistant administrator, Janet McCabe, came before our committee, our EPW committee, to discuss the agency's proposed carbon regulations for new and existing power plants. I asked her to explain why has EPA not had a public meeting on its proposed climate rules in West Virginia. We asked for that. I wasn't alone. Evan asked for that—the Congressman asked for that—many of us did—to ask the EPA to come to West Virginia.

And I was kind of surprised by her response. Because she told me that the public hearings were held where the agency officials were—and this is a direct quote—comfortable going. That was exceedingly unimpressive to me. While it may be uncomfortable for EPA officials to face the coal miners whose livelihoods and whose communities are threatened by these regulations, I think West Virginians deserve to have their voices be heard. So that's why I'm here today. The public hearing on the Environment and Public Works is live streaming on our website, so it will be seen across the Country.

We're going to hear the voices of West Virginians on the devastating impact on the regulations of our fellow West Virginians, because we know we receive 95 percent of our power from coal-fired power plants. The West Virginia coal industry supports families, strengthens our national security and affordably powers not only our State, but provides affordable electricity to our neighbors.

West Virginia exports more than half of the electricity that we produce. And Charles can back me up on that. Just last week, AEP warn notices to—issued warn notices to employees at three West Virginia power plants; the Kanawha River plant in Glasgow, the Sporn plant in New Haven and the Cameron plant near Moundsville. All three plants will close within 2 months. These closures are ahead of schedule and early closures basically because of the EPA's MATS Rule, which is a previous rule different than the one we're discussing today, but still has a great impact.

The upcoming EPA regulations for carbon emissions for power plants that we are here to examine today will have even more devastating impact. I have grave concerns about these regulations. I'm concerned about their cost; the cost to the taxpayer, and the cost to the bill payer.

Numerous studies by well-respected economic analysis firms made clear that the EPA has grossly understated the costs. Findings from these reports show that costs could go up to $479 billion over a 15-year period while causing double-digit electric price increases in 43 States.

Over half of our Country's power comes from coal. And EPA has gone so far to predict that by effectively eliminating one half of our energy generation, we will reduce electricity prices by 8 percent. That just doesn't add up to me.

Here in West Virginia, our monthly electric bills are roughly 23 percent cheaper now than the national average because coal is cheap, reliable and plentiful. I'm very concerned that in formulating these regulations, EPA has not considered the impact on the reliability of the grid.

We actually had a hearing on this last week in our committee. That's one of the reasons I'm very pleased to have Charles Patton from Appalachian Power as one of our witnesses. In his statement, he does speak directly to the impact of these rules on our ability to keep the lights on.

We also have small business owner, Charles Farmer, who will be here shortly. I'm very interested to see how he has borne the brunt of increased electricity prices on his business operations, and how it impacts him and his family and his business.

And the United Mine Workers—we're pleased to have Mr. Gene Trisko who is here to represent the brunt of the president's war on coal in terms of the effect it has on the UMW and coal miners across the Country.

So as we move forward, I'm also concerned—as we talk about emissions, and the lowering of emissions, I'm concerned that the United States is sort of out front here—not sort of out front. We are out front. What are the other nations doing?

And is what we're doing going to really make the impact that those who are putting these forward hope that it will?

So I think we're not rushing this. There are legality issues. We'll get into that today. But what we're doing is really beginning to talk about the economic impacts to our families where the impact is most felt, and that's here in West Virginia.

With that, I'm going to ask Congressman Jenkins to make an opening statement, and then we'll turn to the witnesses.

[The prepared statement of Senator Capito follows:]

STATEMENT OF HON. SHELLEY MOORE CAPITO, U.S. SENATOR FROM THE STATE OF WEST VIRGINIA

Thank you all for being here today. A special thank you to our witnesses for coming to Beckley and to Congressman Jenkins for joining me. This is the first hearing I have chaired back home in West Virginia as a U.S. Senator, but it will not be the last.

Last month, EPA Acting Assistant Administrator Janet McCabe came before the Environment and Public Works Committee to discuss the agency's proposed carbon regulations for new and existing power plants. I asked her to explain why the EPA did not hold a public hearing on its proposed climate rules in West Virginia, despite the large role coal has in our economy and the multiple invitations by Federal and State legislators.

I was shocked, and frankly, appalled by her response.

She told me public hearings were held where agency officials were "comfortable" going.

While it may be uncomfortable for EPA officials to face the coal miners whose livelihoods are threatened by these misguided regulations, West Virginians deserve the opportunity to make their voices heard.

This is why I am here today, holding a field hearing of the Environment and Public Works Committee, which is being live streamed on the Committee website.

EPA will hear the voices of West Virginians on the devastating impact of their regulations on the just under 2 million hard-working West Virginians who receive 95 percent of their electricity from coal-fired power plants.

The West Virginia coal industry supports families, strengthens national security and affordably powers not only my State, but provides affordable electricity to our neighbors—West Virginia exports more than half of the electricity we produce to neighboring States.

Just last week, AEP issued WARN notices to employees at three West Virginia power plants—the Kanawha River Plant in Glasgow, the Philip Sporn Plant in New Haven and the Kammer Plant near Moundsville. All three plants will close within 2 months. These closures are years ahead of schedule, and the early closures are because of the impact of EPA's Mercury and Air Toxins (MATS) rule.

The upcoming EPA regulations for carbon emissions from power plants that we are here to examine today will have an even more devastating impact.

I have grave concerns about these proposed regulations. I am concerned about their cost—the cost to the taxpayer and cost to the bill payer. Numerous studies by well-respected economic analysis firms make clear that the EPA grossly under-estimated the costs. Findings from these reports show costs could get up to $479 billion over a 15-year period while causing double digit electricity price increases in 43 States.

Over half of our country's power comes from coal; yet, EPA has gone so far as to "predict" that by effectively eliminating one-half of our energy generation, we will reduce average electricity prices by 8 percent. That simply does not add up.

Here in West Virginia, our monthly electrical bills are roughly 23 percent cheaper than the national average because our coal is cheap, reliable and plentiful.

I am also very concerned that, in formulating these regulations, EPA has not considered the impact on the reliability of our electricity grid. That is one of the reasons I am pleased to have Charles Patton from Appalachian Power as one of our witnesses. He can speak to the direct impact that EPA regulations have on our ability to keep the lights on.

EPA doesn't have a great track record here. Look at the Mercury and Air Toxins, or MATS, rule. EPA predicted this regulation would result in the closure of about 5,000 megawatts of generating capacity. Instead, the Department of Energy now says that between 50,000 and 60,000 megawatts of generating capacity will be taken offline. That's a huge mistake that would have serious consequences.

It's not the EPA bureaucrats that have to deal with these consequences of a miscalculation. It's the small business owners, like Mr. Chuck Farmer, who will bear the brunt of increased electricity prices on his business operations that not only impact him and his family, but his employees, their families and the surrounding community. It's the United Mine Workers of America that Mr. Trisko is here to represent who will bear the brunt of the President's ongoing war against coal.

Only at a government agency, run by unelected bureaucrats would it make sense to impose regulations that cost billions of dollars, increase the costs of electricity, negatively impact grid reliability, undermine global competitiveness and kill jobs.

Concerning is that estimated emissions growth from China and India render any of these perceived "benefits" pointless.

President Obama is rushing through extreme environmental initiatives without regard for the real-life consequences. Today we are beginning to talk about these economic impacts, to families here, where the impact is felt and our communities are impacted.

STATEMENT OF HON. EVAN H. JENKINS, U.S. REPRESENTATIVE FROM THE STATE OF WEST VIRGINIA

Representative JENKINS. Thank you, Senator. Good morning. And thank you for the wonderful turnout and the interest. Let me first start by thanking Senator Capito for holding this important hearing. She has been a steadfast voice for West Virginia and continues to lead the fight against the administration's regulatory overreach. She's a real champion for our cause.

I also want to thank her and her staff for taking the initiative to hold this important hearing so that the committee can hear the voices from real West Virginians, people who really care about our State's future and understand the issues that we are facing as a State.

As you know—as Senator Capito mentioned just a moment ago, her efforts to try to encourage the EPA to take a proactive position to come to West Virginia. I too had that opportunity, and questioned Administrator McCarthy just a couple of weeks ago, and candidly begged her to come to West Virginia to see the real consequences of her agency's policies and what they will have with regard to the people of West Virginia. And as Senator Capito has run into, she simply says no, unwilling to come.

The EPA continues to overstep its legal authority waging a war on coal. And, yes, it is a war on coal that has destroyed the livelihoods that we have known for generations in West Virginia.

For example, the EPA is retroactively vetoing already issued permits. The permit for the mine in Logan County was issued by the U.S. Army Corps of Engineers after an intensive deliberative process. Families in that area were counting on those new jobs that the mine would help provide and sustain.

But then 4 years later, the EPA swooped in and retroactively vetoed this already issued permit by the Army Corps of Engineers. That was the first time in history that the EPA has ever taken such an action. But the effects of EPA's decisions weren't limited to just the mine operation. They also took away the promise of good-paying jobs and more affordable energy for West Virginians.

Coal is an abundant resource in America. Why are we forsaking one of our largest sources of affordable energy to put ourselves at an economic disadvantage? Why is the EPA forcing consumers to pay more for electricity and for all the goods and products that require electricity to be produced?

The Clean Power Plan we're going to be talking about today—the focus of today's hearing will bring even more economic harm to West Virginia communities. States are being asked by the EPA to decrease emissions by an unrealistic amount. They are being asked to do it in an unreasonable timeframe. If they are unable to comply, they will be fined. All sorts of stakeholder corps, from utilities to State regulators to grid operators have overwhelming concerns over cost, reliability, transmission and grid problems.

Prior to President Obama, coal provided 48 percent of our Nation's electricity. Today we're at 40 percent due to the Mercury Rules and others. Under CPP, coal would be reduced to 30 percent. This has direct impact on coal jobs. We have already suffered disproportionately under this Administration's policies.

From 2009 through 2013, the State of West Virginia lost nearly 9,000 coal jobs. Americans deserve to know the full picture before the EPA moves forward on this aggressive and unprecedented plan. The costs associated with CPP are staggering. The U.S. Chamber of Commerce's Institute for 21st Century Energy estimated that it would lead to 224,000 fewer U.S. jobs on average every year through 2030. Worse, it would force U.S. consumers to pay $289 billion more for electricity in that same time period.

The coal industry has gone through highs and lows before and has recovered. The difference now is that we have a Government pushing policies that is picking winners and losers in industry and forcing utilities to stop using coal.

I look forward to the hearing today and hearing from the witnesses to hear the issues that they are facing and to understand things from their perspective.

Once again, I would like to thank Senator Capito for inviting me to this hearing. This is an important moment for the Appalachian region, for Southern West Virginia, for all of West Virginia and for our Country. This is an important moment. It is critical that we work to preserve our way of life for our children and our grandchildren here in West Virginia.

Thank you, Senator Capito.

Senator CAPITO. Thank you, Congressman. We will begin—I would ask the witnesses—I think most of you have probably testified. Your full statements are submitted into the record. If you could, give us a 5-minute—around a 5-minute synopsis of your full statement. We'll start with that, and then we'll go to questions.

So I'm going to start with Gene Trisko, who is counsel for the United Mine Workers of America. Welcome.

OPENING STATEMENT OF EUGENE M. TRISKO, ATTORNEY AT LAW, ON BEHALF OF THE UNITED MINE WORKERS OF AMERICA

Mr. TRISKO. Thank you. Good morning, Chair Capito and Representative Jenkins. I'm Gene Trisko. I'm an attorney in private practice. I'm here on behalf of the United Mine Workers of America whom I've represented in environmental and climate matters for some 30 years.

The UMWA greatly appreciates this opportunity to testify on the impacts of EPA's proposed Clean Power Plan. This proposed regulation is a neutron bomb aimed directly at the heart of West Virginia's economy and the coal miners, communities, electric generators and allied industries that depend on coal for their livelihoods.

EPA's carbon rule proposes an overall CO_2 reduction equivalent to a 30 percent cut from 2005 emissions with reductions measured against each State's 2012 emission rate in pounds of CO_2 per megawatt-hour of fossil electric generation. West Virginia is assigned a 20 percent reduction by 2030 based on the combined building block approach that EPA developed.

EPA's data indicate that West Virginia's electric utilities and independent power producers achieved a 20 percent reduction of CO_2 emissions measured in tons emitted between 2005 and 2012. In other words, if you were given a fair baseline, you're there. You have already achieved EPA's reduction.

EPA's proposed rule gives no credit for these reductions because it uses a 2012 baseline for determining required emission reductions.

EPA's regulatory impact analysis for this rule shows total U.S. coal-generating capacity declining from 317 gigawatts in 2010 to 195 gigawatts in 2020. That is an overall reduction of 122,000 megawatts of capacity. Of this total, 49 gigawatts can be attributed to the Clean Power Plan with the balance of 73 gigawatts due to compliance with the 2011 Mercury Rule, lower natural gas prices and other factors.

EPA projects that the carbon rule would reduce coal production in the overall Appalachian region—this region stretches from Pennsylvania to Alabama—by 35 percent, from 140 million tons to 91 million tons in the year 2020. West Virginia alone traditionally produces well over 100 million tons of coal a year. Under this rule, the entire Appalachian region would produce 90 million.

The fundamental problems that the EPA carbon rule poses for West Virginia are twofold. First, the majority of West Virginia's coal production is shipped to other States that have even larger emission reduction requirements than West Virginia.

Second, as Senator Capito noted, the majority of the coal-based electricity generated in West Virginia is exported to other States affected by the rule.

In 2013, West Virginia produced 116 million tons of coal. West Virginia's electric utilities and independent power producers consumed 30 million tons of coal from all sources. That's equivalent to just a quarter of the State's total coal production. The rest of it goes somewhere else. You have no control over that.

In 2014, West Virginia power plants generated 88,000 gigawatt-hours of electricity. Your total in-state retail electricity sales were 29,000 gigawatts. That's about one-third of total generation. Two-thirds of it goes to other States. You have no control over it.

In short, there is no compliance option for West Virginia, including potential interstate agreements that can effectively mitigate the adverse impacts of the EPA rule attributable to the compliance actions of other States.

The stakes for West Virginia's economy and jobs are very high. Coal mining in West Virginia generates more than $15 billion of gross State output. Nearly $4 billion of household income, and 75,000 direct and indirect jobs.

EPA's proposal for major expansions of State energy efficiency and renewable energy programs interfere with traditional State authority and energy planning and appear to be well beyond the agency's authority under the Clean Air Act.

We are mindful in this regard of the cautions recently raised by the Supreme Court in UARG versus EPA concerning an overly expansive interpretation of EPA's authority to regulate greenhouse gases under the Clean Air Act.

Finally, we do not know the extent to which other nations will be willing to commit to a truly global program of greenhouse gas reductions. All indications from the United Nations' climate negotiation process point to an extremely difficult outcome in Paris later this year. It is doubtful that those negotiations will lead to meaningful or enforceable emission reduction commitments by the developing countries that are now the world's largest emitters of greenhouse gases.

Thank you for the opportunity to be here today.

[The prepared statement of Mr. Trisko follows:]

Statement of Eugene M. Trisko
On behalf of
United Mine Workers of America, AFL-CIO

Before the
U.S. Senate Environment and Public Works Committee
Field Hearing
Beckley, WV
March 23, 2015

Impacts of U.S. EPA's Proposed Clean Power Plan

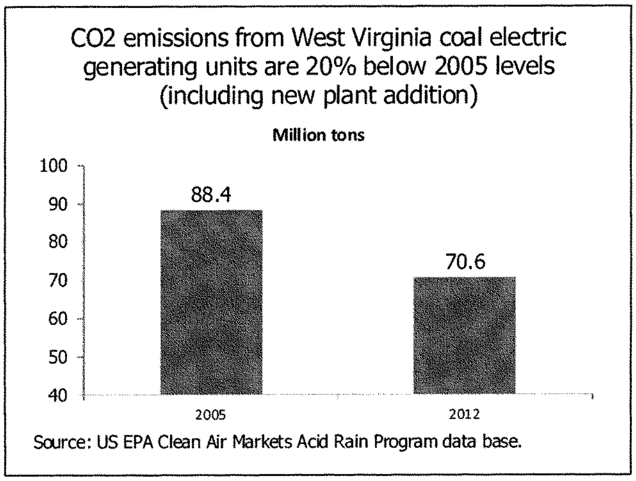
Good morning, Chair Capito and distinguished members of the Committee.

I am Eugene M. Trisko, an attorney in private practice. I am here on behalf of the United Mine Workers of America (UMWA), whom I have represented in environmental and climate matters for some 30 years. A brief bio is attached to my statement.

The UMWA appreciates this opportunity to testify on the impacts of EPA's proposed Clean Power Plan. This proposed regulation is a neutron bomb aimed directly at the heart of West Virginia's economy, and the coal miners, communities, electric generators and allied industries that depend on coal for their livelihoods.

EPA's carbon rule proposes an overall CO2 reduction equivalent to a 30% cut from 2005 emissions, with reductions measured against each state's 2012 emission rate in pounds of CO2 per Megawatt-hour (MWh) of fossil-based electric generation. West Virginia is assigned a 20% reduction target by 2030 based on the combined "building block" approach that EPA developed. These reductions would come from increased use of renewable energy and natural gas, efficiency improvements at power plants, enhanced energy efficiency in the residential, industrial and commercial sectors, and decreased use of coal.

U.S. EPA data indicate that West Virginia's electric utilities and independent power producers achieved a 20% reduction of CO2 emissions, measured in tons emitted, between 2005 and 2012.



CO2 emissions from West Virginia coal electric generating units are 20% below 2005 levels (including new plant addition)

Source: US EPA Clean Air Markets Acid Rain Program data base.

EPA's proposed rule gives no credit for these reductions, because it uses a 2012 baseline for determining required emissions reductions.

EPA's Regulatory Impact Analysis for State Option I shows total U.S. coal generating capacity declining from 317 GW in 2010 to 195 GW in 2020, an overall reduction of 122 GW. Of this total, 49 GW can be attributed to the Clean Power Plan, with the balance of 73 GW due to compliance with the 2011 MATS rule, lower natural gas prices, and other factors. The adverse impacts of the EPA rule are front-loaded in 2020 due to the "interim" targets that EPA has set for each state.

The Federal Energy Regulatory Commission and regional transmission organizations are now engaged in analyses of the potential adverse reliability impacts of the sweeping changes in the U.S. electric supply system envisioned by EPA's rule.

EPA projects that State Option I would reduce U.S. coal production for electric generation by 27%, or 228 million tons in 2020 relative to the base case in 2020. Production for the overall Appalachian region, stretching from Pennsylvania to Alabama, is projected to decline by 35% from 140 million tons to 91 million tons in that year. West Virginia alone traditionally produces more than 100 million tons of coal annually.

The fundamental problems that the EPA carbon rule poses for West Virginia are two-fold: first, the majority of West Virginia's coal production is shipped to other states that have even larger emission reduction requirements than West Virginia; and second, the majority of the coal-based electricity generated in West Virginia is exported to other states affected by the rule.

In 2013, West Virginia produced 116 million tons of coal. West Virginia's electric utilities and independent power producers consumed 30 million tons of coal from all sources in 2013, equivalent to just 26% of total production. (DOE/EIA Annual Coal Report 2013).

In 2014, West Virginia power plants generated 88,047 GWh of electricity, with total in-state retail electricity sales of 28,919 GWh, equivalent to one-third of total generation. (DOE/EIA, Electric Power Monthly, March 2015).

In short, there is no compliance option for West Virginia – including potential interstate agreements - that can effectively mitigate the adverse impacts of the EPA rule attributable to the compliance actions of other states.

The UMWA has long advocated increased investment in CCS technologies as a means to reduce carbon emissions while preserving coal as a mainstay of U.S. electric generation. Unfortunately, government funding and regulatory support for CCS projects have been disappointing, leaving natural gas as the principal option for future electric generation.

The stakes for West Virginia's economy and jobs are very high. Coal mining in West Virginia generates more than $15 billion of gross state output, nearly $4 billion of household income, and 75,000 direct and indirect jobs.[1]

Our estimates of the national job impacts of the Clean Power rule indicate the potential loss of 52,000 permanent direct jobs by 2020 in the utility, rail and coal sectors due to power plant retirements, and the loss of 167,000 total direct and indirect jobs. These direct jobs are all high-paying jobs, typically in rural communities such as those here in southern West Virginia, without opportunities for comparable employment. These impacts do not consider any of the plant closures and job losses expected over the next few years due to the MATS rule and other factors, or the impacts of higher electricity and natural gas prices on other industries.

EPA's proposals for major expansions of state energy efficiency and renewable energy programs interfere with traditional state authority in energy planning, and appear to be well beyond the agency's authority under the Clean Air Act.

In UMWA's meetings with EPA prior to the June 2014 proposal, we urged EPA to focus the rule on options for reducing emissions within the plant fence line. This is consistent with our legal understanding of the scope of Section 111(d). The agency has taken a far more expansive view of its authority. We are mindful in this regard of the cautions recently raised by the Supreme Court in *UARG v. EPA* (2014) of an overly-expansive interpretation of the authority to regulate greenhouse gases under the Clean Air Act.[2]

---

[1] Estimates are based on 2013 West Virginia coal production and fob mine price from DOE/EIA Annual Coal Report 2013 (2014) and US Department of Commerce RIMS II multipliers for the West Virginia coal mining industry.

[2] In *UARG*, the Court found that an EPA interpretation of its authority under the Clean Air Act would be unreasonable if:

> *"...it would bring about an enormous and transformative expansion in EPA's regulatory authority without clear congressional authorization. When an agency claims to discover in a long-extant statute an unheralded*

UMWA does not oppose efforts to reduce carbon emissions under the Clean Air Act. Our concerns are about the overall design of this proposed rule, and its expansive reach into regulatory and policy arenas that traditionally are the province of state legislatures and regulators.

Finally, we do not know the extent to which other nations, particularly large developing countries, will be willing to commit to a truly global program of greenhouse gas reductions. Our actions will have negligible climate impacts in a world economy that is using more coal and other fossil fuels every day. All indications from the UN climate negotiation process point to extreme difficulty in reaching an agreement in Paris later this year that would lead to meaningful - or enforceable - emission reduction commitments by the developing countries that are now the world's largest emitters of greenhouse gases.

Thank you for the opportunity to appear today.

---

power to regulate 'a significant portion of the American economy,' Brown & Williamson, 529 U. S., at 159, we typically greet its announcement with a measure of skepticism. We expect Congress to speak clearly if it wishes to assign to an agency decisions of vast 'economic and political significance.' Id., at 160; See Also *MCI Telecommunications Corp. v. American Telephone & Telegraph Co.*, 512 U.S. 218, 231 (1994); *Industrial Union Dept., AFL-CIO v. American Petroleum Institute*, 448 U.S. 607, 645-646 (1980) (plurality opinion). ...

". . .in EPA's assertion of that authority, we confront a singular situation: an agency laying claim to extravagant statutory power over the national economy while at the same time strenuously asserting that the authority claimed would render the statute "unrecognizable to the Congress that designed" it. " ...

"We are not willing to stand on the dock and wave goodbye as EPA embarks on this multiyear voyage of discovery. We reaffirm the core administrative-law principle that an agency may not rewrite clear statutory terms to suit its own sense of how the statute should operate." Slip op. at 19-23, footnotes omitted, emphasis added.

Senator CAPITO. Thank you.

Now, I'd like to ask Charles Patton to make his opening statement. Charles is president of Appalachian Power Company. Welcome. Thank you for being with us.

STATEMENT OF CHARLES PATTON, PRESIDENT AND CHIEF OPERATING OFFICER, APPALACHIAN POWER COMPANY

Mr. PATTON. Thank you. Chairman Capito, I'd like to thank you for inviting me here today. And it's always a pleasure to see you, Congressman Jenkins. We appreciate the energy and enthusiasm which you bring to represent the State of West Virginia.

I appreciate this opportunity to offer the views of Appalachian Power Company on the carbon dioxide rules for existing power plants that have been proposed by the Environmental Protection Agency.

Headquartered in Charleston, West Virginia, Appalachian Power Company serves approximately 1 million customers in West Virginia, Virginia and Tennessee. We are a subsidiary of American Electric Power. AEP and its six other subsidiary utilities deliver safe, reliable and affordable electric service in eight additional States, making AEP one of the Nation's largest generators of electricity.

Additionally, AEP's transmission network is the Nation's largest and most robust with over 400,000 miles of high-voltage transmission. As one of the Nation's largest utilities and one of the Nation's historically most coal-dependent utilities due to our proximity to this abundant and stably priced natural resource, we have been active in the conversation surrounding the appropriateness of the Clean Power Plan as a policy direction for reducing the carbon footprint of the Nation's electric power supply industry.

I have filed some 26 pages of testimony outlining our concerns. As a major coal burner, I'm sure that you will not find it surprising that Appalachian Power and our parent company, AEP, has serious concerns around the proposed EPA plan.

In that 26 pages of testimony, I have listed some concerns. Are EPA's technical assumptions correct?

Has the EPA appropriately quantified the cost of its proposal?

Are there significant reliability concerns that are not receiving appropriate attention?

Has the EPA overreached its legal authority? These are questions and issues that are raised in my testimony.

Having reviewed a significant number of the comments filed by States this past fall, it is clear that the concerns delineated a great deal in my testimony are also shared in some form by the vast majority of the States in this Nation.

Therefore, in lieu of offering you a laundry list of concerns, I would like to share with you my personal experience which gives me great pause regarding the appropriateness of the EPA's proposal.

Approximately 5 years ago, I became the president and chief operating officer of Appalachian Power Company. When I arrived, it was on the heels of a $2.2 billion capital spending program placing scrubbers on our large baseload coal-fired generating stations. At that time, given the prevailing cost of alternatives, it was the best option for our customers. A position that was endorsed by State regulators and key stakeholders involved in the regulatory approval process.

Despite being the least cost solution—yes, that's right, coal is the least cost solution. The results were electric rates that did increase on average 40 percent. These investments and resulting rate increases were common for utilities with large coal fleets at that time.

States like Louisiana, Tennessee, Mississippi, Alabama and West Virginia have the highest average residential electric consumption rates in the Nation. There are logical reasons for this outcome; the rural nature of these States, the lack of retail natural gas in rural areas for gas heating, and a strategic cost advantage of electricity. And, unfortunately, also the socioeconomic factors related to the quality of the housing stock in those States.

In West Virginia, over 400,000 low income and middle income families spend 20 percent of their after-tax income on energy. Approximately 25 percent of my residential customers are delinquent on their electric bills.

Additionally, many of my customers in the metals industries which have electric-intensive production processes are also struggling to remain profitable. In fact, the West Virginia legislature has enacted legislation specifically targeting its large energy-intensive industries to help address this reality.

Congressman Jenkins, you were there when that—you were part of passing that legislation.

But how much more can they afford? I'm not sure. However, as we proceed in addressing carbon, I would ask that this committee and all of Congress consider the following. Economics and existing EPA regulations have resulted in a profile where today 60 percent of AEP's generating capacity is coal compared to well over 80 percent in 2000. By 2026, the percentage is expected to drop to 45 percent.

Then if you go back to 2005, you will find that our decrease to date in carbon output is somewhere north of 21 percent, not including future closures planned in 2015 as a result of our efforts to comply with EPA's Mercury and Air Toxics Standards.

APCO and AEP do not dispute the legitimacy of pursuing policies that reduce our Nation's carbon footprint. However, we would suggest to you that we have grave concerns regarding the affordability, technical assumptions and need for the Clean Power Plan as it is proposed.

Thank you very much.

[The prepared statement of Mr. Patton follows:]

WRITTEN TESTIMONY OF CHARLES PATTON

PRESIDENT AND CHIEF OPERATING OFFICER

APPALACHIAN POWER COMPANY

BEFORE THE U.S. SENATE

ENVIRONMENT AND PUBLIC WORKS COMMITTEE

March 23, 2015

Chairman Capito, thank you for inviting me here today. I appreciate this opportunity to offer the views of the Appalachian Power Company (APCo) on the carbon dioxide (CO2) rules for existing power plants (the "Clean Power Plan") that have been proposed by the U.S. Environmental Protection Agency (EPA). My name is Charles Patton, and I am the President and Chief Operating Officer of Appalachian Power Company (APCo). Headquartered in Charleston, West Virginia, APCo serves 960,500 retail customers in West Virginia and Virginia. The parent company of APCo is American Electric Power (AEP). Based in Columbus, Ohio, AEP, through its public utility operating companies and other subsidiaries, ranks among the nation's largest generators of electricity. AEP companies own over 37,000 megawatts of generating capacity in the U.S and deliver electricity to more than 5.3 million customers in 11 states, and will be directly affected by the requirements of the final rule. AEP companies also own the nation's largest electricity transmission system, a nearly 40,000-mile network that includes more 765-kilovolt extra-high-voltage transmission lines than all other U.S. transmission systems combined. AEP's transmission system directly or indirectly serves about 10 percent of the electricity demand in the Eastern Interconnection, the interconnected transmission system that covers 38 eastern and central U.S. states and eastern Canada, and approximately 11 percent of the electricity demand in ERCOT, the transmission system that covers much of Texas. AEP's utility units operate as AEP Generation Resources, AEP Texas, Appalachian Power (in Virginia, West Virginia and Tennessee), Indiana Michigan Power, Kentucky Power, Public Service Company of Oklahoma, and Southwestern Electric Power Company (in Arkansas, Louisiana and east Texas).

AEP's generating fleet employs diverse fuel sources – including coal, nuclear, hydroelectric, natural gas, oil, and wind power. Due to the location of our service area and the historic importance of coal to the economies of our states, approximately 60 percent of our current generating capacity uses coal to generate electricity. My testimony provides the perspectives of both AEP and APCo on the proposed GHG rules, and offers both the national and the West Virginia impacts of these rules.

AEP believes strongly in the merits of fuel diversity in generating electricity. This is a key issue in the topic of this hearing on the impact of 111(b) and 111(d) on energy production and electricity generation. Today, coal-fueled power plants account for approximately 60 percent of AEP's generating capacity, while natural gas represents 23 percent and nuclear 5 percent. The remaining capacity comes from wind, hydro, pumped storage and other sources, including energy efficiency. By 2026, we project that our coal-fueled generating capacity will drop to 45 percent, while natural gas capacity will increase to 33 percent.

WEST VIRGINIA IMPACTS OF CLEAN POWER PLAN

In 2013, coal provided 95% of West Virginia's electricity[1] and is responsible for 89,000 direct and indirect jobs within the state.[2] However, the proposed Clean Power Plan (CPP) would likely result in substantial reductions in coal-fired generation and coal-related jobs by requiring an 8% reduction in the state's CO2 emission rate by 2020 and a 20% reduction by 2030.[3] These required emission cuts would force West Virginian's to switch to more expensive energy sources, which come at a substantial cost premium to existing low-cost coal-fired generation. The over 400,000 low-income and middle-income families in West Virginia, representing 59% of the state's households, already spend 20% of their after-tax income on energy. Modeling by NERA Economic Consulting projects that the CPP will cause a 12% increase in electricity prices for West Virginia consumers, with a peak year increase of 14%. Under another scenario (what would happen if West Virginia consumers do not significantly reduce their electricity use), electricity prices in West Virginia could increase by 28%, with a peak year increase of 21%.[4]

These added costs come at a time where West Virginia is already making substantial progress in reducing its CO2 emissions, largely through the announced retirement of 18 coal units totaling 2,237 MW. However, through the building block approach utilized by EPA in developing the CPP, West Virginia is assumed to bear the burden of additional significant reductions without appropriate credit for committed coal retirements. In fact, West Virginia's remaining coal EGUs, (after the announced retirements), would have the lowest average CO2 emission rate for coal units in the US, 2,048 lbs CO2/net electricity MWh, according to the West Virginia Department of Environmental Protection.

---

[1] U.S. Energy Information Administration, *Electric Power Monthly*, February 2014.
[2] National Mining Association, http://www.countoncoal.org/states/.
[3] http://www2.epa.gov/sites/production/files/2014-06/20140602-state-data-summary.xlsx & http://www2.epa.gov/sites/production/files/2014-05/documents/20140602tsd-goal-computation.pdf.
[4] NERA Economic Consulting, *Potential Impacts of the EPA Clean Power Plan*.

EPA's building block formula assumes West Virginia would be able to decrease average coal plant heat rates by 6%, increase renewable energy output by 700% and cut customer demand by 10% through energy efficiency by 10% by 2030.[5] As AEP and WV DEP and many others have noted in their comments to EPA, there are significant problems with how these figures were developed and calculated as well as errors in the data used. This in turn has meant that EPA has substantially overstated the amount of reductions in CO2 that can be achieved thru its Building Blocks. As a result, EPA is ultimately requiring new and dramatic changes in the energy supply mix when the electric utility industry is still coming to grips with the dramatic loss of a substantial amount of base load coal capacity that has supported the grid over many decades.

U.S. EPA's own analysis of the proposed guidelines predicts that 46,000 to 49,000 megawatts of coal-fueled generation will be shut down no later than 2020 as a result of this proposal.[6] That's in addition to approximately 71,000 megawatts of coal-fueled generation that EPA concludes has retired or will retire between 2010 and 2016. This means about one-third of all existing coal-fueled power plants, enough generation to power 60 million homes, would be gone in just five years. EPA estimates that most of these combined retirements (about 120,000 megawatts) occur by 2016. The additional retirements will happen at plants that have made, or are just completing, significant environmental investments to comply with other EPA regulations. Closing this much generation in such a short timeframe raises serious concerns about the ability to maintain reliability and meet peak demand, particularly in periods of extreme weather. Higher-cost replacement generation will need to be built and significant investment in transmission and other mitigation will be necessary to maintain the reliability of the electricity grid – all of which will take time and ultimately, will increase the cost of electricity.

---

[5] EPA, GHG Abatement Measures Technical Support Document, June 2014.

[6] EPA, Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants, June 2014.

The proposed state emission rate requirements were calculated by U.S. EPA assuming that natural gas combined cycle plants will run 70 percent of the time, far above current operating levels in most states, which is unrealistic. Most existing natural gas plants were not designed, built or permitted to run at those levels. And, in many areas, the natural gas pipeline infrastructure does not exist to support those levels of operation. The U.S. fleet of natural gas combined cycle power plants has never averaged a 70 percent capacity factor. Even in 2012, when natural gas prices were very low, the natural gas combined cycle fleet only achieved a 51 percent annual capacity factor. Significantly higher use of natural gas for electricity generation will increase natural gas prices and result in higher electricity costs and higher home heating costs in many states. It also will increase overall energy costs in the United States. This is highly problematic because in the past several years low natural gas prices have been providing important support for a still tenuous U.S. economy.

The ultimate impacts to AEP customers and WV as whole will largely depend upon the structure and stringency of the final rule and the path laid forward for compliance within West Virginia's State Implementation Plan. However, based on the proposed rule, AEP has serious concerns with the potential cost and reliability implications of this proposal. AEP has submitted substantial comments outlining concerns and errors within the rule to EPA in an effort to help protect WV ratepayers and WV jobs.

IMPORTANCE OF FUEL DIVERSITY TO COAL AND WEST VIRGINIA

The combination of recent regulations related to clean air; the 111(b) rule on new units; and the 111(d) rule on existing units will have a severe impact on fuel diversity. It is appropriate, therefore, to begin with a summary of why fuel diversity has been, and must continue to be, one of the central objectives of energy policy in the United States. Coal, including coal mined in West Virginia, has played a central role in this policy for the last century.

The importance of fuel diversity cannot be overstated given its implications for assuring economic and energy security. Too great a reliance upon any one energy source (particularly those with a history of price volatility) creates a significant risk exposure to electricity price escalation and supply disruptions. As has been proven repeatedly across the globe, such exposure can lead to severe impacts on the supply and price of electricity for residential, commercial, and industrial customers.

For example, the relatively recent nuclear catastrophe in Japan serves as a sobering reminder of what can happen if a single energy source is abruptly removed from use. In 2011, an earthquake and tsunami devastated shoreline communities and seriously damaged the Fukushima Daiichi nuclear power plant. Resultant radiation leaks and a greatly eroded public faith in safety of nuclear power led to the shutting down of all of Japan's 48 nuclear reactors for mandatory maintenance and safety checks. To date, no units are back in service, though several have finally received preliminary approval to restart sometime this year.[7] Heavily populated areas of the country have faced the realities of rolling blackouts, while manufacturing facilities had to reduce output, with some making moves to relocate abroad. Meanwhile, natural gas prices in Japan nearly tripled as power producers scrambled to fill the massive void left in their energy infrastructure.

Domestic energy disruptions and their consequences are clearly evident by such disasters as Hurricane Katrina in 2005, where nine oil refineries were shut down for an extended period of time and 30 oil platforms were either damaged or completely destroyed, dramatically hampering oil and gas production. United States natural gas prices spiked following the disaster and for months afterward remained more than double the price over the previous year.

There is another unique feature to coal that must be considered from an energy security perspective. Coal is a solid and physically stable energy resource that can be safely stockpiled at the power plant site. A typical power plant takes advantage of this feature by keeping an inventory of 30 to 60 days of supply of coal at the plant site. This is an incredibly valuable characteristic when considering the risks associated with supply interruptions of other fuels, such as natural gas. If storms, natural disasters, or other forces interrupt major gas pipeline infrastructure, gas-fired power plants immediately cease to produce electricity and cannot resume production until infrastructure repairs are made. Coal plants, on the other hand, can continue to operate if the major fuel supply is compromised. Similarly, nuclear power enjoys the benefit of large reserves of fuel capacity on the plant site. This is a factor of fundamental value to any energy security solution and has national security benefits as well – particularly given the abundant reserves of coal in the United States.

---

[7] http://dw.de/p/1Eo0X

AEP has a long history of using a variety of fuels within its generation mix and has increasingly has sought to diversify its resources. AEP's leadership and innovation in our core generation, transmission and distribution services have led to improvements in efficient and clean production and delivery of our product. We accomplished these improvements through continual advances in generation technology efficiency, improved environmental performance, reduced transmission line losses, implementation of energy audits, support of improvements in the efficiency of end-use appliances and fixtures, and improved delivery of real-time pricing and usage information for the electric grid. This innovation has helped insulate our customers from fluctuations in the cost of electricity, reduced overall costs and diversified the ways we provide service to our customers.

Much of AEP's eastern service territory, due to its proximity to Appalachian coal, has typically been served by coal-fired generation. These large coal reserves have served AEP's customers well, resulting in some of the lowest costs for electricity in the country and fueling economic expansion. However, the advent of nuclear power allowed AEP to begin to diversify away from coal in the 1970's and further diversification occurred in the 2000's with natural gas combined cycle generating facilities being added to the system, in addition to purchases of wind power, due in large part to government tax incentives. Over the past twelve years AEP has added more than 5,000MW of natural gas fuel diversity, which has enabled our company to switch between fuel sources based on price fluctuations of fuels over time.

REGULATORY BARRIERS TO FUEL DIVERSITY

There are numerous barriers to fuel diversity within the electric generation fleet; however our most pressing concerns are the new federal environmental regulations and the lack of an energy policy promoting diversity and therefore energy security. As an example, the proposed CO_2 NSPS for new sources effectively prohibits the construction of new coal-fired facilities unless CCS is included – and unproven and extraordinarily expensive technology. These proposed CO_2 performance standards come in the wake of other new environmental regulations, most notably the Mercury and Air Toxics Standards. Due to these new EPA rules and other factors, electric utilities have already publicly announced their plans to shut down or convert 462 coal-fired generating units, totaling about 72,000 MW.[8] This represents over 20 percent of the U.S. coal fleet will be shut down within the next few years. Due to these regulations, our nation's electric grid will become increasing reliant on natural gas for new generation capacity, likely eliminating both diversity and flexibility in new power plant builds. Federal policy should support fuel diversity, not preclude it.

FUEL DIVERSITY UNDERMINED BY GHG RULE FOR NEW PLANTS

In addition to the concerns related to the Clean Power Plan, which are proposed New Source Performance Standards (NSPS) for existing electric generating units (EGUs) under section 111(d) of the Clean Air Act, AEP also has serious concerns with the proposed section 111(b) NSPS regulations which would apply to new EGUs. EPA initially proposed a 111(b) rule in

---

[8] http://www.americaspower.org/sites/default/files/Coal%20Unit%20Retirements%20JANUARY%2025%202015.pdf

April 2012, but then subsequently withdrew the rule and re-proposed a new rule in September 2013. The rule sets separate standards for certain natural gas-fired stationary combustion turbines and for fossil fuel-fired utility boilers and integrated gasification combined cycle (IGCC) units. While AEP supports the distinction between the unit types the proposed standard of 1,100 lb-CO2/MWh for fossil fuel-fired utility boilers and integrated gasification combined cycle (IGCC) units is highly problematic.

The proposed 1,100 lb-CO2/MWh standard was set by EPA based on a Best System of Emission Reduction (BSER) determination, which incorrectly found that CCS can be commercially used to control CO2 emissions. AEP completely disagrees with EPA's determination, based in large part due to first-hand experience with a CCS demonstration project, within the state of West Virginia, at our Mountaineer unit. CCS technologies have not been adequately demonstrated and any objective analysis would prove this to be the case. Furthermore, even though EPA has proposed CCS as part of its BSER determination it fails to provide adequate or requirements for successful short term or permanent sequestration.

As proposed, the 111(b) rule as it would effectively preclude the use of coal in new generating units without carbon capture and storage (CCS). As CCS is not a commercially viable technology the proposed rule is setting de facto energy policy with respect to new electric generating units. Based on these concerns and others, AEP has requested that EPA once again withdraw the rule and re-proposed based on existing, proven technologies that result in lower CO2 emission rates, not speculative ones such as CCS.

FUEL DIVERSITY UNDERMINED BY GHG RULE FOR EXISTING PLANTS

The proposed Clean Power Plan states that "Regulations of the Administrator under this paragraph shall permit the State in applying a standard of performance to any particular source under a plan submitted under this paragraph to take into consideration, among other factors, the remaining useful life of the existing source to which the standard applies." The facilities and equipment to which the proposed guidelines apply are capital-intensive, long lived assets, many of which have historically operated for 50 to 60 years. In addition, at most of these facilities, significant additional investments have recently been made to comply with other environmental regulations.

EPA has a statutory duty to "tak[e] into account the cost of achieving such reduction" when determining the "best system of emission reduction." The most centrally relevant costs are the costs to the existing sources required to make the emission reductions mandated under section 111(d). EPA has failed to identify, much less consider, those costs. Instead, EPA has estimated macroeconomic net costs to the entire nation. Under EPA's proposal, virtually all of the reductions in CO2 emissions from affected EGUs come from reduced utilization of coal-fired EGUs. EPA must, at a minimum, determine the diminution in asset value to the owners of those existing sources, and the local and regional economic disruption and unemployment that would result from the proposal.

However, for purposes of this rulemaking, EPA assumes that all existing coal-fired sources that will be operating in 2020 and beyond should gradually reduce their generation and be replaced by lower or non-emitting generation or EE measures over a fifteen-year period. The most egregious example of this scenario is in Arizona, where EPA's model predicts that all coal fueled EGUs will disappear before the final goals become effective in 2030. EPA projects that implementation of the proposed rule will result in significant changes in how and where electricity is generated. The agency estimates that as a result of implementing the proposed rule up to an additional 49 GW of existing coal-based generation will retire by 2020, that existing NGCC units will be utilized more, and that new renewable energy development and energy efficiency programs will be implemented.

As an example, under its assessment of its preferred 111(d) option, EPA projects that an incremental 41 to 44 GW of generation will be taken offline in 2016 relative to the Base Case. Many of the units projected to retire are currently in the process of making multi-million dollar investments in emission controls to comply with MATS. Such investments have been made due to programs like the MATS rule and the Regional Haze program "best available retrofit technology" or BART requirements. In analyzing the cost-effectiveness of controls under the BART guidelines, EPA has often used the "remaining useful life" of a source as an input to that analysis, and its default assumption is that existing sources will continue to operate for 20 years after completing the retrofit of such controls.

However, EPA's own models demonstrate that the integrated operation of the four building blocks would result in the retirement of many additional sources, none of which have reached the end of their "remaining useful life." EPA has therefore assumed billions of dollars of stranded investment associated with current retrofit projects and existing plant, property and equipment, which may not be fully depreciated. In regulated jurisdictions, these costs will be passed on to customers in the form of higher rates. In deregulated jurisdictions, these stranded investments will result in a loss of shareholder value. The magnitude of the recent investments in the existing fleet is staggering. AEP alone has spent approximately $3.5 billion to upgrade its existing units, and several compliance projects are still underway. Nowhere does EPA take into account the loss of these assets, and their potential impact on customer rates. Nor does EPA explain how it can override the discretion Congress specifically vested in the states to avoid such adverse economic impacts. EPA must address these costs, and revise its proposal to allow states the latitude to design programs that do not result in the confiscation of assets, or prematurely force retirements rather than preserving the remaining useful lives of these units.

BACKGROUND: OVERARCHING AND SERIOUS PROBLEMS WITH THE PROPOSED 111(d)

EPA states that the proposed Clean Power Plan ("CPP") is *"an important step toward achieving the GHG emission reductions needed to address the serious threat of climate change."*[9] However, in taking that step, EPA has overstepped its statutory authority, and ignored the legal, technical, and practical limitations that govern the production, delivery, and use of electricity in the United States. Efforts have already been made, and continue to be made, by AEP and others to reduce greenhouse gas emissions from fossil-fueled electric generating units ("EGUs"). Additional dramatic changes in the nation's portfolio of generation resources and their associated emissions will continue in the near-term due a number of regulatory and market drivers. For example, implementation of the Mercury and Air Toxics Standards,[10] and Regional Haze requirements[11] will result in AEP alone permanently removing over 6,000 megawatts ("MW") of coal-fired generating capacity from service and converting an additional 730 MW from coal- to gas-firing. Others are taking similar steps. Yet EPA provides no comprehensive assessment of the emission reductions resulting from these actions in order to determine whether, and if so, how much more reduction can and should be achieved, consistent with the requirements of section 111 of the Clean Air Act.

---

[9] 79 Fed. Reg. 34,833.

[10] 40 CFR Part 63, Subpart UUUUU.

In its fact sheet released with the CPP, EPA claimed that the proposal would result in a 30 percent reduction in CO_2 emissions from 2005 levels for the power sector by 2030.[12] However, based on the guidance released on November 13, 2014, the actual reduction in CO_2 emissions from the existing fossil fleet required by this proposal on a mass basis is 30 percent *from 2012 levels* by 2030.[13] For the AEP fleet, this means that the 20 percent reduction in emissions already achieved from 2005 levels is largely disregarded, and deep additional cuts will be required to satisfy the goals established by EPA.

There are a number of legal, technical, and practical concerns and uncertainties that make implementation of the proposed rule unworkable. Many of these unknowns relate to the assumptions underlying each building block, regulatory strategies that are unproven, levels of implementation that are technically and practically unachievable, or interactions that are not feasible to design or enforce within the existing statutory and regulatory authorities of the states.

---

[11] 40 CFR §51.308.

[12] http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-overview.

[13] *Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, Notice, Additional information regarding the translation of emission rate-based CO_2 goals to mass-based equivalents*, 79 Fed. Reg. 67,406 (November 13, 2014).

EPA acknowledges that some of these issues "introduce practical enforceability considerations under a state plan." But instead of fully evaluating these issues, EPA relies exclusively on the purported "flexibility" that the agency believes states have to address any challenges associated with implementation. This claimed "flexibility" is illusory. There is no way for states to assure that individual generating units will achieve the emission reductions associated with block 1, and no technical basis upon which EPA can conclude that the projected emission reductions will actually occur, because EPA does not evaluate the extent to which such measures have already been implemented, and did not properly account for the heat rate increases associated with recent control equipment installations. There is no way for states to control system dispatch decisions that are entrusted to regional authorities, and simply attempting to "freeze" emissions from designated facilities in 2020 based on projected emissions and generation that accommodate the effects EPA hopes to achieve through building blocks 1 and 2.

The proposed rule does not adequately account for the many factors that introduce variability into existing units' utilization and emissions, including weather patterns, unanticipated equipment problems, and changes in local load conditions. The output of renewable resources similarly is heavily influenced by weather conditions, equipment condition, and other factors that are neither controlled nor controllable by the designated facilities or the states, and EPA has misinterpreted existing state standards by ignoring the extent to which those standards are currently satisfied by participation in multi-state REC markets, the extent to which they are satisfied in whole or part through energy efficiency measures or alternative payments, and the extent to which they rely on unique resources whose status as "renewable" energy sources in any future section 111(d) plan is uncertain. These errors make EPA's cumulative targets unreasonable and arbitrary.

Finally, EPA has no authority to regulate the behavior of consumers, and its simplistic evaluation of the potential for future energy efficiency measures ignores fundamental aspects of program design and achievability. There are errors in each and every one of the blocks upon which the state goal calculation is based that make the final result arbitrary and capricious. All of these errors inflate the prospects for future emission reductions, and simply shift the search for effective ways to meet the arbitrary goals from one building block to another and beyond, to measures EPA admits are not cost-effective, in a continuous loop of legally, technically, and practically flawed options that impairs the development of any workable compliance solution.

BACKGROUND: IMPACTS OF 111(d) ON TRANSMISSION & RELIABILITY

In addition, EPA has failed to identify and consider the costs of the proposed transformation of the existing electricity systems, such as additional transmission facilities, additional natural gas pipeline capacity, additional transmission support capacity, additional financing costs of intermittently used generating capacity, and additional maintenance, repair and replacement due to increased ramping up and down of dispatchable generation. It is implausible to interpret the mandate to consider cost in section 111(d) as excluding the costs pinpointed on specific existing sources and specific local and regional economic disruption and unemployment. EPA's proposal is deficient and arbitrary in its omission of: 1) any analysis of the direct cost impacts to owners of existing coal-fired EGUs that would be expected or forced to shut down or reduce utilization; and 2) any analysis of the full costs of ensuring a reliable bulk power supply system in a rapid transition to lower carbon and intermittent electricity generation.The reliability and resource adequacy analysis performed by EPA is incomplete and inaccurate. It asks the wrong questions and provides answers developed using the wrong tools. Any analysis of the achievability of the CPP must be based on the tools used by reliability organizations to assess power flows under the conditions projected to occur as the CPP is implemented. Because EPA assumes that there will be dramatic changes in the composition, location, and characteristics of the generation fleet as a result of the CPP, such an analysis must be performed iteratively by organizations with the expertise and knowledge to analyze the dynamic nature of the impacts of these changes.

The North American Electric Reliability Corporation ("NERC") recently released a preliminary assessment of the stability and reliability of the grid if the changes envisioned in EPA's modeled outputs for its cost-benefit analysis actually occurred in 2020.[14] These changes will strain reliability and essential services, require expansion of the transmission grid, and are inconsistent with the planning horizons used to implement transmission reliability enhancements. The Southwest Power Pool ("SPP") has performed a similar analysis of the potential reliability impacts within the SPP region. SPP found that: "1) the CPP will impact the reliability of the bulk electric system; 2) the timing proposed by EPA for compliance is infeasible; and 3) the proposed CPP will have material impacts on the market-based dispatch of electric generating units within the SPP region."[15] AEP's own internal analysis of the SPP and

---

[14] http://www.nerc.com/pa/RAPA/ra/Reliaiblity%20Assessment%20DL/Potential_Reliability_Impacts_of_EPA_Proposed_CPP_Final.pdf

[15] http://www.spp.org/publications/CPP %20Reliability%20Analysis%20Results%20Final%20Version.pdf

PJM regions within which it operates yielded similar results. Any future proposals must be accompanied by a comprehensive analysis that demonstrates that the security and reliability of the bulk power system will not be compromised.

The gap between the Clean Power Plan's initial deadlines and the earliest in-service dates possible for new infrastructure will create an atmosphere ripe for massive blackouts that would jeopardize the nation's economy and homeland security. Its timelines are so aggressive, we cannot hope to achieve the infrastructure development it will require. The reliability concerns promulgated by the Clean Power Plan stem from inadequate pipeline and electric generation and transmission infrastructure to achieve its goals, and inadequate time to plan for newly developed infrastructure. Failure to address these reliability issues will undermine the environmental goals of the EPA and simultaneously undermine the reliability of the nation's electric grid because that failure will result in band-aid responses that ultimately will result in sub-optimal solutions.

BACKGROUND: SUMMARY OF ISSUES WITH FOUR BUILDING BLOCKS OF 111(d)

EPA's Interpretation of "BSER" is Fatally Flawed

This proposal is wholly different from any prior emission limitation, standard, or guideline developed by EPA under the CAA. If adopted, the CPP would establish an expansive and unprecedented program to regulate the production, delivery, and use of electricity in the United States. The assumptions that EPA uses to develop state goals supersede the authority granted to the Federal Energy Regulatory Commission ("FERC") under the Federal Power Act, contain significant and fundamental technical flaws regarding the nature and operation of electricity generators and the electricity grid, and intrude upon authority reserved to the states. The proposal also is contrary to the express requirements of section 111 of the CAA, and EPA's own regulations, in several significant respects.

A fatal defect in EPA's CPP is the proposal's dependence upon an abstract, out-of-context interpretation of "system" in the phrase "best system of emission reduction" in the section 111 definition of "standard of performance." EPA's unprecedented interpretation of the word "system" in the "standard of performance" definition is disassociated from, and in conflict with, the interlinked CAA definitions of "stationary source," "existing source," "emission limitation," and "performance standard," and with the legislative history of Section 111. It is also in conflict with EPA's existing regulations that implement section 111, and at odds with EPA's interpretation and application of section 111 throughout its 44-year history. Rather than reflecting the degree of emission limitation achievable by applying a demonstrated technology-based (or work practice) system of emission reduction to the affected EGU, as the statute plainly directs, the proposal requires a reduction in the hours of operation and/or rate of production (or complete shutdown) of affected EGUs, a result contrary to the text and structure of the statute, and that could not have been imaginable to the Congresses that enacted and amended the CAA in 1970, 1977, and 1990.

Never before has EPA claimed the authority to limit productive capacity or control the rate of customer usage of a particular product, and the assertion of authority to do so here has no foundation in the CAA. Because EPA's interpretation would purport to give EPA broad power to regulate human behavior, EPA's interpretation of "system of emission reduction" must be rejected.

Building Block 1 Comments

EPA mischaracterizes observed variability in heat rate at coal units as being "evidence" that existing coal-based generating units are not being adequately operated or maintained.[16] Heat rate performance is influenced by a variety of known and unknown, controllable and uncontrollable factors, whose interaction is unit-specific and varies throughout the life of the unit. Moreover, EPA's examination of opportunities to improve heat rate either ignores or does not fully consider the following factors:

- the availability, technical viability, and economic feasibility of potential improvement opportunities at individual units;
- heat rate improvement measures that have already been implemented;
- unit-specific factors that influence the magnitude and sustainability of potential heat rate improvements; and
- other environmental regulatory requirements that may mask or eliminate opportunities for potential heat rate improvements.

There is also a long history of successful advancement and adaptation of new technologies, operating procedures, materials, and equipment upgrades that have allowed units within the existing fleet (both coal-fired and non-coal units) to maintain and improve efficiency through adoption of best practices. Had EPA fully considered these factors, the agency would have correctly concluded that both the proposed 6% and alternative 4% targets for heat rate improvements are overly aggressive, and cannot feasibly be implemented by the majority of existing coal-based generating units because:

---

[16] "GHG Abatement Measures TSD". U.S. EPA. June 10, 2014. p. 2-1

- There is a wide range of inherent limitations on the potential for heat rate improvements, including original design, geographic location, availability of space, emission controls, and prior improvement efforts;
- Unit efficiency naturally degrades over time;
- There is no accurate method to measure heat rate in real time;
- Heat rate improvements may be masked by control technology installations or changes in duty cycle; and
- Remaining useful life will affect the economic feasibility of continued efficiency investments.

There is no single emission standard or limitation that is achievable or adequately demonstrated for all regulated sources. Instead, EPA should rely on Section 111(h)(1) of the CAA, which authorizes the Administrator to identify design, equipment, work practice, or operational standards, or a combination thereof, when it is not feasible to establish a standard of performance, and develop a work practice standard for EGUs. Such a standard would assure that cost-effective changes are routinely made at existing units, consistent with the criteria contained in section 111(d).

Building Block 2 Comments

Building block 2 is based on EPA's generalized assumption that *all* existing NGCC units can be redispatched to sustainably achieve a 70% capacity factor, and that the additional generation provided by the existing NGCC units will *exclusively* offset generation from other, higher-emitting, existing fossil-fueled units. The underlying analysis that supports this assumption relies on inaccurate data, and generally represents a poor understanding and application of the basic concepts and operating metrics used to assess historic and future unit performance. The result is an assumed level of performance that simply has not been adequately demonstrated to be achievable across the fleet of existing NGCC units.

Further, EPA fails to explain how this building block is consistent with section 310 of the Clean Air Act,[17] which specifically preserves the authority of all other federal agencies, when such requirements for "environmental dispatch" would effectively override the system of security constrained economic dispatch created by the Federal Energy Regulatory Commission ("FERC") and implemented through regional transmission organizations ("RTOs"), independent system operators, and other balancing authorities, as required by the Federal Power Act.[18]

Even if such a concept could be incorporated into a section 111(d) standard, the level of operation assumed by EPA in calculating the state goals contains fundamental errors, such as: (1) relying on nameplate capacity instead of net demonstrated capacity (which results in about a 10% increase in the goals that cannot reasonably be achieved); (2) including units that are not designated facilities; (3) failing to accurately and consistently account for units that operated for only a portion of 2012, or were not yet operating; and (4) failing to adequately evaluate the availability of gas pipeline capacity to deliver fuel and transmission capacity to deliver power, and the time and cost necessary to increase capacity if it is not already available. EPA's own policy case modeling does not achieve the level of operation assumed by EPA in calculating the state goals.

---

[17] 42 U.S.C. § 7610(a).
[18] 42 U.S.C. § 824(b).

EPA must present a proposal that, at a minimum, is grounded in accurate, complete data and that reflects the actual operation of the electricity grid. Given the egregious nature and scope of concerns to be resolved in building block 2 *alone*, EPA should withdraw the current proposal and publish a new proposed rule for public comment.

Building Block 3 Comments

EPA has not cited, and AEP has not discovered, any statutory basis for the inclusion of generation from new and existing non-emitting nuclear and renewable resources in its calculation of state goals to regulate emissions of fossil-fueled EGUs. Such units are not "affected facilities" in the listed source categories for which these guidelines are proposed, nor would they be subject to any standards under section 111 if they were "new." EPA's expansion of its regulatory grasp far exceeds the scope specifically authorized by Congress, and invades the reserved powers of the States under the Tenth Amendment to the U.S. Constitution.

Moreover, EPA's use of individual state renewable portfolio standards to establish "regional goals" that each state must achieve is ill-informed, and overlooks distinctions among these state standards that either significantly reduce the absolute value of those standards, or rob the states of flexibility in implementing the goals, or both. EPA has also insufficiently evaluated the technical potential and cost of renewable resources across the states, and ignored significant questions related to the expansion of both intrastate and interstate transmission resources, regulatory processes, cost allocation, and timing.

Any goals established by EPA in the final rule cannot rely on nuclear or renewable resources. However, EPA should prescribe procedures for the development of state plans that allow states to determine if or how renewable resources may be included in their compliance plans.

Building Block 4 Comments

EPA also does not have clear authority from Congress to dictate energy policies that control customer demand, including the degree to which energy efficiency ("EE") measures should be adopted by individual customers.[19] Even if such authority existed, EPA has failed to demonstrate that the level of EE used to calculate the state goals is achievable or has been adequately demonstrated. Specifically, EPA ignores the expert evaluations of the majority of states regarding a reasonably achievable level of EE, the pace of increase in EE achievement, and a reasonable level of costs to achieve those proposed EE levels. Further, the data and methodology that the agency used in establishing these levels for all states in a one-size-fits-all manner ignores many fundamental differences between the states that affect the nature and scope of achievable EE measures and rates of growth. EPA did not use a transparent process in estimating the costs of the proposed EE levels, did not consider all cost elements of EE, and did not give adequate consideration to the ways such costs will affect customers. EPA's failure to specifically identify the evaluation, measurement and validation ("EM&V") methods required for a satisfactory state plan, and its failure to assess whether such EM&V measures are currently applied in the programs identified as "best practice standards," provide an inadequate basis for commenters to determine the actual impact of the proposed guidelines. Accordingly, EPA should not assume specific levels of EE achievement in developing any state-specific goals, but states should retain the flexibility to determine if or how EE measures may be included in their compliance plans.

---

[19] Indeed, in the context of EPA's authority under Section 169 of the CAA to specify what is the "best available technology" for regulated pollutants in a new source review ("NSR") permit, the Supreme Court noted with approval that, "BACT may not be used to require 'reductions in a facility's demand for energy from the electric grid,'" and that "BACT should not require every conceivable change that could result in minor improvements in energy efficiency, such as the aforementioned light bulbs." Rather, the Court confirmed that BACT can only be required for pollutants that the source itself emits, and that permitting authorities should consider whether the proposed regulatory burden outweighs any emission reductions that can be achieved. *UARG v. EPA*, 134 S.Ct. 2427, 2448 (2014). These same principles should apply to the BSER, which is based on technology that can be applied to emissions from the regulated source, and must satisfy the statutory balancing of costs, other environmental affects, and the emission reductions actually achieved.

Implementation Concerns

The flaws identified within each of the building blocks collectively lead to serious concerns related to the practical implementation of the CPP. Because the errors identified in the development of each building block lead to a significant overstatement of its potential contribution to reductions in emissions from existing fossil-fueled EGUs, the combined whole represented in the state goals has not been adequately demonstrated and is not achievable. All flexibility that would have been present had EPA accurately assessed each building block evaporates.

Moreover, EPA's proposal to extend compliance responsibilities to entities other than the "designated facilities" exceeds EPA's and states' authorities under the CAA, creates uncertainty regarding the ultimate enforceability of the state goals, and raises procedural and substantive due process concerns for sources within the regulated source categories if states elect to follow EPA's advice and reduce their plan requirements to goals enforceable only against those sources. EPA has ignored the requirement under section 111(d) to provide states with the flexibility to adjust the stringency of the final performance standard or the timing of the ultimate compliance schedule based on the remaining useful life of the regulated sources. And the timeline to achieve compliance is unreasonable, particularly for building blocks 1 and 2, both of which are proposed to be fully implemented by 2020. EPA has no authority to dictate the timing of implementation or to establish interim goals, and these are issues that should be reserved to the states as they develop final performance standards.

Senator CAPITO. Thank you.

Our next witness is Dr. L. Jeremy Richardson, who is the senior energy analyst, Union of Concerned Scientists, Washington, DC. And I understand your father is in the audience. I want to welcome him as well. Welcome, Dr. Richardson.

STATEMENT OF L. JEREMY RICHARDSON, Ph.D., SENIOR ENERGY ANALYST FOR THE UNION OF CONCERNED SCIENTISTS

Mr. RICHARSON. Thank you very much, Senator Capito and Representative Jenkins.

As you said, I'm a senior energy analyst at the Union of Concerned Scientists. UCS is the Nation's leading science-based nonprofit working for a healthy environment and a safer world. I have a very unique perspective on the issues before you today. As a scientist, I understand the urgency to reduce carbon emissions to protect the planet's climate. As the brother, son and grandson of West Virginia coal miners, the question of how we go about tackling climate change is deeply personal to me.

First, on behalf of UCS's more than 450,000 supporters, I want to say today that we strongly support the Environmental Protection Agency's efforts to limit carbon emissions from power plants under the Clean Air Act. Simultaneously, however, we want to emphasize the need for special consideration for the families and communities that are facing the negative consequences for the transition away from coal.

Human-induced climate change is already having impacts that are being felt by people here in West Virginia, our Nation and around the world. If we collectively fail to make deep reductions in our carbon emission, we will greatly increase the risks of serious economic, health and environmental consequences from accelerating sea level rise, storm surges, heat waves, drought, wildfires, frequent heavy downpours and increase hurricane intensity. These impacts are a direct consequence of the increasing concentration of greenhouse gases like carbon dioxide in our planet's atmosphere primarily caused by the fossil fuels that we burn for energy.

These facts compel us to act and to act decisively. In doing so, however, we must recognize that some regions of our Country are facing a heavier burden than others in this transition to a less fossil-intensive electricity system.

The proposed Clean Power Plan provides a sound and flexible framework for reducing emissions from the power sector. But it is not ambitious enough in its overall result of a 30 percent reduction in emissions by 2030.

Our analysis shows that EPA significantly underestimated the potential for renewables such as wind, solar and geothermal energy resources that emit no carbon and are already delivering safe, reliable and affordable power to consumers all around the Country.

As we all know, the coal industry faces challenging times. Many blame environmental regulations entirely for the downturn. But the truth is that regardless of who occupies the White House, the industry faces strong and persistent headwinds. Multiple market factors are making coal fired power too expensive relative to other cheaper, less polluting options like natural gas, renewable energy and energy efficiency. Thankfully, West Virginia has many assets that it can leverage to diversify its economy. But we must let go of the idea that coal is all we've got.

Communities all around coal country from Beckley to Welch to Pikeville are eager to have this conversation. They realize that times are changing and they are calling for leadership. Over 200 people from a wide range of perspectives attended a forum that UCS organized in September 2013 to talk about the State's bright future. Participants pointed to the State's topnotch work force, its natural resources, of course, a multitude of opportunities for recreation and tourism, emerging opportunities in advanced manufacturing and much more. The conversations have continued from the ground up.

Williamson is remaking itself as a healthy community focused on sustainability. Communities across West Virginia have been participating in a series of dialogs called What's Next West Virginia. And a few leaders are listening as evidenced by initiatives in Eastern Kentucky and in Southern West Virginia. Even the President's budget includes significant investments in the Appalachian region.

Together with Federal policymakers, States, especially West Virginia, should help ensure that economic diversification and resources for workers in communities are an important part of their compliance plans. Fortunately, there are a variety of policies both within the context of State compliance plans and through complementary policies enacted by State legislatures that can help, including market-based mechanisms and tax policies, like West Virginia's Future Fund that was established last year. By working together, we cannot only establish a strong standard to protect the planet's climate, but also ensure that workers in communities have a fresh economic opportunity as market forces continue to drive a shift away from coal.

I do not accept this as an either/or proposition. Our children and our grandchildren will face the risks of a vastly different climate caused by our failure to act to reduce emissions today.

My young niece, and maybe someday her children and grandchildren, will face an uncertain future if we fail to invest in the workers and communities that have built this Nation's wealth. It is much harder, but it is imperative that we do both.

Thank you.

[The prepared statement of Mr. Richardson follows:]

Written Testimony of Dr. Jeremy Richardson
Senior Energy Analyst, Union of Concerned Scientists

Senate Environment and Public Works Committee Field Hearing
"Regional Impacts of EPA Carbon Regulations: The Case of West Virginia"
March 23, 2015

My name is Jeremy Richardson and I am a senior energy analyst at the Union of Concerned Scientists (UCS). UCS is the nation's leading science-based nonprofit working for a healthy environment and a safer world. We appreciate the opportunity to provide input on this critical issue.

I have a unique perspective on reducing carbon emissions from the burning of fossil fuels. As a scientist, I understand the **urgency to reduce emissions to protect the planet's climate**. As the brother, son, and grandson of West Virginia coal miners, the question of **how we go about tackling climate change is deeply personal to me.**

First, on behalf of UCS's more than 450,000 supporters, I want to say that we strongly support the Environmental Protection Agency's (EPA's) efforts and authority to limit carbon emissions from fossil fuel-fired power plants through the Clean Power Plan (CPP). **Simultaneously**, however, I want to emphasize the need for **special consideration** for the families and communities facing the negative consequences of the transition to a cleaner, low carbon energy system.

UCS provided extensive comments on the Clean Power Plan to EPA as part of its public comment period that closed on December 1, 2014. I have attached our full comments for inclusion in the record, and I highlight some key points here.

Climate Change is Real and Caused by Human Activity

Human-induced climate change is **already having impacts** that are being felt by people here in West Virginia, our nation, and around the world. If we collectively fail to make deep reductions in our carbon emissions, we will greatly increase the risk of **serious economic, health, and environmental consequences** from accelerating sea level rise, storm surges, heat waves, drought, wildfires, more frequent heavy downpours, and increased hurricane intensity.

These impacts are a direct consequence of the **increasing concentration of greenhouse gases like carbon dioxide** (CO_2) in our planet's atmosphere. Power plants are the largest single source of U.S. CO_2 emissions, representing about 40 percent of the total. Reducing emissions from the electric power sector is therefore crucial to our overall efforts to tackle climate change. UCS has worked for many years to educate the public on the science of climate change and to advance solutions. I have attached two recent UCS reports on climate change: "Encroaching Tides"[1] and "National Landmarks at Risk."[2]

These facts compel us to act, and to act decisively. In doing so, we must recognize that some regions of our country are **facing a heavier burden** than others in accelerating this transition to a less fossil-intensive electricity system.

Carbon emissions are driving climate change with accelerating pace

Evidence of the heat-trapping role of carbon dioxide (CO_2) in the atmosphere was established in 1859 and by the end of that century the discovery emerged that fossil fuel emissions could cause a shift in Earth's climate.[3] The first confirmation that these emissions were already changing Earth's temperature emerged during the 1930s.[4]

The accelerating pace of emissions after these discoveries is alarming, with over half emitted since 1970 of the total human CO_2 emissions between 1750 and 2010.[5] The annual atmospheric CO_2 increase (2.9 ppm) over 2012-2013 was the highest over the 1984 to 2013 period of record.[6] Accelerating emissions has occurred despite the worldwide trend, since 1850, in the mix of primary energy supply shifting away from less carbon intensive fuels from primarily biomass to primarily coal to more oil and gas in the mix.[7] The latest tracking for each country's share of CO_2 emissions ranks China (27 percent) and the United States (17 percent) as the top two in 2011.[8] The bulk of 2012 U.S. heat-trapping emissions was in the form of CO_2 (82 percent) with nearly a third of all U.S. emissions that year coming from electricity generation (32 percent).[9] Carbon standards aimed at reducing emissions from existing U.S. power plants tackles one of the largest current sources of global CO_2 emissions in the world.

---

[1] UCS 2014. Encroaching Tides: How Sea Level Rise and Tidal Flooding Threaten U.S. East and Gulf Coast Communities over the Next 30 Years. Online at http://www.ucsusa.org/global_warming/impacts/effects-of-tidal-flooding-and-sea-level-rise-east-coast-gulf-of-mexico#.VQxARuEuwfg

[2] UCS 2014. National Landmarks at Risk: How Rising Seas, Floods, and Wildfires Are Threatening The United States' Most Cherished Historic Sites. Online at: http://www.ucsusa.org/global_warming/science_and_impacts/impacts/national-landmarks-at-risk-from-climate-change.html#.VQxAtuEuwfg

[3] Fleming, J.R. 1998. Historical Perspectives on Climate Change, Oxford University Press.

[4] Callendar, G.S. 1938. The artificial production of carbon dioxide and its influence on temperature. Quarterly J. Royal Meteorological Society 64:223-240.

[5] IPCC, 2014: Summary for Policymakers, In: Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[6] WMO. 2014. WMO Greenhouse Gas Bulletin: The State of Greenhouse Gases in the Atmosphere Based on Global Observations through 2013. World Meteorological Organization. ISSN 2078-0796.

[7] Blanco G. et al., Chapter 5: Drivers, Trends, and Mitigation, in Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

[8] U.S. Energy Information Administration. Indicators CO_2 Emissions Tables for 2011. Online at http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8&cid=regions&syid=2007&eyid=2011&unit=MTCDPP.

[9] EPA. 2014. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2012. U.S. Environmental Protection Agency, Washington D.C. The EPA 430-R-14-003.

Future risks of catastrophic climate outcomes add urgency for emissions reductions

Certain catastrophic climate outcomes are a growing risk unless substantial progress in global heat-trapping emissions occurs. The northern permafrost soil organic carbon pool is estimated to be around 1672 petagrams carbon (PgC).[10] This is larger than the anthropogenic budget of around 1,000 PgC emissions to stay below a global mean temperature rise of 2°C above the 1861–1880 period; half (445-585 PgC) has already been emitted by 2011.[11]

Keeping this region cold enough to prevent the release of these vast stores of carbon in the form of methane (CH_4) and CO_2, trapping heat and warming Earth even faster, is a key factor in the urgency for substantial emissions reductions. Reasons include the processes that lead to amplified warming in the Arctic which pose risks of increased permafrost degradation rates.[12] The loss of the upper few meters of permafrost is projected to decrease 37 percent to 81 percent by the end of this century under RCP2.6 and RCP8.5 future scenarios respectively.[13] Carbon released from permafrost is irreversible for millennia.[14]

Another catastrophic climate outcome, that is irreversible for millennia, is ice sheet collapse.[15] Long before total collapse, significant ice sheet shrinking would transform coastlines of the world to a degree that would be unrecognizable to many coastal residents of today. Paleoclimate evidence from the last interglacial period, around 130,000 years ago, occurred with the combined shrinking of the perimeter of the Greenland ice sheet and the West Antarctic Ice Sheet with an associated sea level rise of more than 4 to 6 meters above current sea level.[16] Today's CO_2 levels in the atmosphere are much higher than when these changes occurred over the last interglacial. At 6 meters additional sea level rise, south Florida and the Mississippi Delta regions of Louisiana would be severely inundated as well as large portions of other coastlines around the world.[17]

Climate change impacts in the U.S. are growing

Already, people living in the U.S. are exposed to climate change impacts that vary in severity depending on the season, location, socioeconomic factors as well as local, regional, and national resilience policies.[18] Land ice and warming oceans both contribute to global sea level rise with the former at a much higher increasing pace than the latter.[19,20] This combined with local land elevation shifts and the loss of natural barriers has increased so-called "nuisance flooding" in areas of the U.S. with more than 300 percent increase (Norfolk, VA, San Francisco, CA, and Washington DC) to more than 900 percent increase (Baltimore, MD, and Annapolis, MD) in the number of flood days in recent years (2007–2013) compared to around 50 years earlier (1957–1963).[21] The future risk of nuisance flooding is directly tied to the rate at which the U.S. and the world choose the pace of emissions going forward. Emissions really matter to many coastal communities. For example, in Annapolis, MD, which currently experiences nearly 50 tidal flood events per year, the community could face over 220 such events under an intermediate-low scenario or over 380 such events under the highest emissions scenario.[22] Since there are only 365 days a year, that means tidal flooding twice a day at current Annapolis locations or for all practical purposes—inundation.

---

[10] Kuhry, P., Grosse, G., Harden, J. W., Hugelius, G., Koven, C. D., Ping, C.-L., Schirrmeister, L. and Tarnocai, C. 2013. Characterisation of the Permafrost Carbon Pool. Permafrost Periglac. Process., 24:146–155. doi: 10.1002/ppp.1782

[11] Collins, M., R. Knutti, J. Arblaster, J.-L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver and M. Wehner. 2013. Long-term Climate Change: Projections, Commitments and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[12] Lawrence, D.M., Slater, A.G., Tomas, R.A., Holland, M.M., and Deser, C. 2008. Accelerated Arctic land warming and permafrost degradation during rapid sea ice loss. Geophys. Res. Lett. 35 DOI 10.1029/2008GL033985

[13] IPCC. 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[14] *Ibid.*

[15] *Ibid.*

[16] Overpeck J.T., B.L. Otto-Bliesner, G.H. Miller, D.R. Muhs, R.B. Alley, and J.T. Kiehl. 2006. Paleoclimatic Evidence for Future Ice-Sheet Instability and Rapid Sea-Level Rise. Science:311:1747-1750.

[17] Overpeck, J.T. and J.L. Weiss. 2009. Projections of future sea level becoming more dire. PNAS. 106: 21461–21462.

The growing risk of extreme events that lead to too much water (or snow) or too little water (and associated consequences) have cost lives, property and at times transformed local communities when severe enough to permanently displace a critical number of residents. The fundamental consequence of more water vapor in the atmosphere from global warming, has led to an increase in precipitation volume in the heaviest annual events, in Alaska and the Continental U.S. (e.g., Northeast (71 percent); Midwest (37 percent).[23]

Higher temperatures increase soil and surface water evaporation and plant transpiration rates leading to increased drought risk in some regions, seasons or time periods.[24] Warmer temperatures in the Western U.S. have brought earlier snowmelt leaving high mountain forests hotter and drier, especially comparing the dry La Niña years compared with La Niña years decades earlier, increasing the risk of large wildfires.[25] Federal fire suppression costs, in 2012 dollars, have increased from around $440 million in 1985 to around 1.7 billion in 2013.[26]

---

[18] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds. 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

[19] Church, J.A., N.J. White, L.F. Konikow, C.M. Domingues, J.G. Cogley, E. Rignot, J.M. Gregory, M.R. van den Broeke, A.J. Monaghan, and I. Velicogna. 2011. Revisiting the Earth's sea-level and energy budgets from 1961 to 2008. Geophys. Res. Lett. 38. doi:10.1029/2011GL048794.

[20] Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Appendix 3: Climate Science Supplement. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 735-789. doi:10.7930/J0KS6PHH.

[21] Sweet, W., J. Park, J. Marra, C. Zervas, S. Gill. 2014. Sea Level Rise and Nuisance Flood Frequency Changes around the United States. NOAA Technical Report NOS CO-OPS 073 and online at http://www.noaanews.noaa.gov/stories2014/20140728_nuisanceflooding.html.

[22] Spanger-Siegfried, E., M.F. Fitzpatrick, and K. Dahl. 2014. Encroaching tides: How sea level rise and tidal flooding threaten U.S. East and Gulf Coast communities over the next 30 years. Cambridge, MA: Union of Concerned Scientists.

[23] Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Ch. 2: Our Changing Climate. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT.

[24] *Ibid.*

[25] Westerling A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfireactivity. Science 313:940–943.

[26] Cleetus, R., and K. Mulik. 2014. Playing with fire: How climate change and development patterns are contributing to the soaring costs of western wildfires. Cambridge, MA: Union of Concerned Scientists.

Significantly reducing U.S. existing power plant emissions in the next decade and beyond can help reduce the risks of negative consequences from climate change in the U.S. and the world. As part of the global effort to reduce emissions, in 2009 the U.S. committed to reducing emissions 17 percent below 2005 levels by 2020,[27] and recently announced a commitment to further reduce emissions 26 to 28 percent below 2005 levels by 2025.[28] These commitments would put the U.S. on a path to the goal of reducing emissions by at least 80 percent by 2050, a goal consistent with international agreements. Scientists conclude that to meet international goals to limit warming to 2°C above preindustrial levels,[29] the world must stay within a budget of around 1,000 PgC emissions.[30] For the U.S. to make good on those commitments, the power sector will need to cut emissions by more than the estimated reductions from the Clean Power Plan of 30 percent below 2005 levels by 2030.

West Virginia is not immune from the impacts of climate change

Like the rest of the country and the world, the state of West Virginia is witnessing the impacts of a changing climate. In June 2014 the Allegheny Highlands Climate Change Impacts Initiative[31] organized a conference focusing on local climate impacts in the highlands region. Experts discussed the changes in precipitation and temperature, impacts on forests and streams, wildlife, and economic impacts on outdoor recreation on the region.[32]

EPA's Proposed Carbon Standards are Flexible and Must Be Strengthened

The Clean Power Plan provides a **sound framework for reducing emissions** from the power sector, but is **not ambitious enough in the overall result** of a 30 percent reduction in emissions in 2030 relative to 2005. UCS analysis shows that, by increasing the contribution from renewable energy in the CPP, we could cost-effectively increase emission reductions to 40 percent below 2005 levels by 2030. We detailed our methodology in our comments to the agency, and I have also attached a shorter policy brief on our findings for the record.

UCS **supports** EPA's proposal to **incorporate renewable energy (RE) and energy efficiency (EE) in state compliance plans.** Renewables such as wind, solar, and geothermal energy emit no carbon, and are already delivering **safe, reliable, and affordable** power to consumers. They also help diversify the electricity mix, improve public health, strengthen state and local economies, and reduce the risks of over reliance on natural gas.

---

[27] United States. 2010. Copenhagen Accord submission. Online at http://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/unitedstatescphaccord_app.1.pdf

[28] The White House. 2014. U.S.-China Joint Announcement on Climate Change and Clean Energy Cooperation. Fact sheet. Online at http://www.whitehouse.gov/the-press-office/2014/11/11/fact-sheet-us-china-joint-announcement-climate-change-and-clean-energy-c

[29] National Research Council. 2010. Limiting the magnitude of future climate change. Washington, DC: National Academies Press.

[30] Collins, M., R. Knutti, J. Arblaster, J.-L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver and M. Wehner. 2013. Long-term Climate Change: Projections, Commitments and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[31] http://www.alleghenyclimate.org/

[32] Allegheny Highlands Climate Change Impacts Initiative 2015. On the Chopping Block: The Impacts of Global Warming and Climate Change on the Mid-Atlantic Allegheny Highlands. Online at: http://www.alleghenyclimate.org/documents/Updated%201-19-15%20OTCB%20Report.pdf

EPA used four "building blocks" to determine the Best System of Emission Reduction (BSER) and establish emission rate reduction goals for each state. For the renewables block, EPA has really proposed an **"average"** system of emission reduction, seriously underestimating the true potential for renewable energy to cut carbon emissions. EPA's state renewable energy targets are in many cases close to a business-as-usual approach—four states had **more renewable generation in 2012** than their EPA targets for **2030**.

States could be **more ambitious** in using renewables to reduce emissions. Costs of renewable energy have fallen dramatically. For example, prices for residential and commercial solar systems fell by half from 2009 to 2013,[33] and dropped an additional 9-12 percent over 2014.[34] Meanwhile, the cost of wind power dropped 43 percent in the last four years—and is now **competitive with power from new fossil fuel plants** in some regions of the country.

EPA's framework also includes the option for states to comply on a multi-state or regional basis, which not only rewards early actors like the RGGI states but also creates an opportunity for new or expanded **multi-state collaborations to drive down emissions at a lower cost.**

Challenges Facing Coal

As we all know, the **coal industry faces challenging times.** Many blame environmental regulations entirely for the downturn, but the truth is that **regardless of who occupies the White House**, the industry faces strong and persistent headwinds. The **primary driver is economics**—cheap natural gas has **dramatically reduced** coal's role in the electricity sector, and competition with other coal-producing regions has reduced the competitive advantage of Central Appalachian coal. After 150 years, we have mined the highest quality and easiest-to-get seams, and the rest is getting harder—and **more expensive**—to get.[35]

The future of the coal industry, even without this rule, is uncertain at best,[36] and it has already declined, particularly in Central Appalachia, due to cheap and abundant natural gas, competition with other coal mining regions, decreasing labor productivity (and increasing costs), and earlier environmental regulations. Although the EPA concludes that the proposed standard likely will result in an increase in net jobs nationally, **it must be recognized that job impacts will be unevenly dispersed—some regions and states will be winners, and others will experience economic consequences from a shift away from coal.** Although the agency has no authority under the CAA to provide assistance to states facing negative impacts, it can and should offer guidance to those states on ways to help to address such concerns. **Coal-heavy states, in turn, should consider using compliance plans as an opportunity to help diversify their economies.**

---

[33] Solar Energy Industry Association 2014. Q3 2014 Solar Market Insight fact sheet: http://www.seia.org/sites/default/files/Q3%202014%20SMI%20Fact%20Sheet.pdf.

[34] Solar Energy Industry Association 2014. Solar Market Insight Report 2014 Q4. http://www.seia.org/research-resources/solar-market-insight-report-2014-q4

[35] McIlmoil, R., E. Hansen, N. Askins, and M. Betcher. 2013. The continuing decline in demand for Central Appalachian coal: Market and regulatory influences. Downstream Strategies, 2013. Online at http://www.downstreamstrategies.com/documents/reports_publication/the-continuing-decline-in-demand-for-capp-coal.pdf.

[36] Richardson, L. J., R. Cleetus, S. Clemmer, and J. Deyette. 2014. Economic impacts on West Virginia from projected future coal production and implications for policymakers. Environmental Research Letters, 18 Feb 2014. 9(2): 024006. doi:10.1088/1748-9326/9/2/024006.

In short, multiple market factors are making **coal-fired power too expensive** relative to other **cheaper, less polluting options** like natural gas, renewable energy, and energy efficiency.

Economic Justice: Job Creation and Worker Transition

The EPA and states must pay particular attention to both environmental and economic justice issues. **Overburdened communities, including low-income and minority populations, often face the greatest impacts from criteria air pollutants; conversely, coal workers may face the loss of their livelihoods in the transition to a clean energy economy.** The impacts of climate change will disproportionately affect certain communities, such as the poor, the elderly, and the very young, who are most vulnerable to health impacts, as well as minority and disadvantaged communities, which notably already face significantly greater health impacts due to poor air quality. Similarly, **without foresight and planning, policies to address the threat of climate change could negatively impact communities that depend on fossil-related industries for economic activity and jobs.**

In its proposal, the EPA outlined specific elements of an approvable state compliance plan. Given the complex nature of the proposed standard, the agency should specify a menu of options that states could use to address both environmental and economic justice concerns. **State compliance plans should direct resources to the most impacted communities, while reducing emissions, protecting workers, and mitigating direct health impacts.** Shutting down old, inefficient, and polluting coal plants[37] can help reduce health impacts in overburdened communities[38] while investments in renewable energy and energy efficiency can help create jobs and strengthen local economies, which is of critical importance to communities heavily reliant on coal and related industries.

In our comments to the EPA, UCS recommended that the agency emphasize—and provide guidance to states on—**the potential for job creation and economic development from investments in renewable energy and energy efficiency and in supporting industries, especially manufacturing.** With the rapid decline in cost and corresponding increase in deployment of renewable energy resources like wind[39] and solar,[40] fossil generation is under increasing competition from cleaner alternatives for electricity. The proposed standard for carbon emissions represents an opportunity for states to amplify or jumpstart investments in both renewables and efficiency and to stimulate local economies. Many studies have demonstrated the job growth and economic benefits of such investments. Most recently, a report looking at California as a case study[41] demonstrates how federal, state, and construction industry policies have led to the development of nearly 5000 MW and the creation of more than 15,000 jobs.[42] Thanks to strong labor agreements, not only are workers well-paid and receive solid health and pension benefits, but also contractors have contributed $17.5 million for training programs. Solar development in California "is preparing a new generation of California blue collar workers for a future of skilled and productive work and a life of financial security."[43]

---

[37] Cleetus, R., S. Clemmer, E. Davis, J. Deyette, J. Downing, and S. Frenkel. 2012. Ripe for retirement: The case for closing America's costliest coal plants. Cambridge, MA: Union of Concerned Scientists, November 2012. Online at http://www.ucsusa.org/assets/documents/clean_energy/Ripe-for-Retirement-Full-Report.pdf.

[38] Wilson, A. et al. 2012. Coal blooded: Putting people before profits. Online at http://www.naacp.org/page/-/Climate/CoalBlooded.pdf.

[39] American Wind Energy Association (AWEA). 2014. U.S. wind industry annual market report 2013. Washington, DC: AWEA.

[40] Solar Energy Industries Association (SEIA). 2014. Solar energy facts: 2013 year in review. Washington, DC: SEIA. Online at www.seia.org/sites/default/files/YIR%202013%20SMI%20Fact%20Sheet.pdf, accessed on September 15, 2014.

[41] Philips, P. 2014. Environmental and economic benefits of building solar in California. Donald Vial Center on Employment in the Green Economy. Institute for Research on Labor and Employment, UC Berkeley. Online at

Fortunately, there are a **variety of policy mechanisms, both within the context of state compliance plans and through complementary policies enacted by state legislatures, to retrain workers and invest in economic diversification.** Many such policies have the potential to generate revenue that the states can then invest as they see fit. Policies could include:

- **Market-Based Mechanisms.** The Regional Greenhouse Gas Initiative (RGGI) offers an example of how state collaboration on market-based solutions could generate revenue for states as they lower carbon emissions. For example, in 2012 RGGI states invested 73 percent of auction revenue in energy efficiency programs, which is expected to save participants $1.8 billion on electricity bills over the lifetime of the measures.[44] During the first compliance period from 2009-2012, **RGGI auctions generated $912 million in proceeds and produced $1.6 billion in net present value to the (then) ten-state region, corresponding to almost $33 per capita spread throughout the region.**[45] Cumulatively, from 2009-2012, 65 percent of proceeds went to energy efficiency, 17 percent to direct bill assistance, 6 percent to clean and renewable energy, and 6 percent to GHG abatement—but states direct their own auction revenue as they see fit. Coal-heavy states that join regional programs could decide to direct auction revenue to worker retraining and economic diversification, and should be encouraged to do so. California's AB 32 similarly sets up a market-based mechanism for reducing emissions that generates revenue for the state.

- **Carbon Fees.** Sub-national governments have enacted prices on carbon emissions. British Columbia, for example, enacted a carbon tax[46] in 2008; the revenue neutral program in fiscal year 2013-14 is expected to generate $1.2 billion in proceeds to offset other taxes. Such policies can be used to generate revenue that could be directed to affected workers and communities.

- **Permanent Mineral Trust Funds.** Many resource-rich states have enacted permanent mineral trust funds, which levy a special tax on companies for right to remove resources from the ground.[47] Wyoming, for example, enacted its program in 1974, and as of 2013, the

---

http://laborcenter.berkeley.edu/environmental-and-economic-benefits-of-building-solar-in-california-quality-careers-cleaner-lives/.

[42] Includes 10,200 construction jobs, 136 permanent O&M jobs, and over 3,700 additional jobs (induced).

[43] Philips 2014.

[44] RGGI 2014. Regional Investment of RGGI CO_2 Allowance Proceeds, 2012.

[45] Hibbard et al. 2011. The economic impacts of the Regional Greenhouse Gas Initiative on ten Northeast and Mid-Atlantic states. The Analysis Group.

[46] http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm.

[47] Boettner T., J. Kriesky, R. McIlmoil, and E. Paulhus. 2012. Creating an economic diversification trust fund: Turning nonrenewable natural resources into sustainable wealth for West Virginia. West Virginia Center on Budget and Policy, January 2012. Online at http://www.wvpolicy.org/downloads/WVEconomicDiversificationTrustFundRpt013012.pdf.

fund was worth $5.88 billion.[48] In March 2014, West Virginia established the **Future Fund,**[49] similarly designed to **direct a fraction of severance tax revenue from mineral resources (notably, including coal) to economic diversification and development focusing on regions where the extraction takes place.** Although no revenue is currently being directed toward the Future Fund due to other budget priorities, the legislation specifically allows for other sources of revenue to be deposited into the fund.

- **Renewable Electricity Standards.** In addition to helping states meet their carbon reduction goals, RES policies[50] can spur renewable development. Some states have even defined their RESs to designate a portion of RE development from in-state resources to support local job creation. Studies find limited cost impacts from such policies, and some states have quantified measurable economic benefits from the programs.[51]
- **Energy Efficiency Resource Standards.** Similarly, policies that promote energy efficiency in homes and businesses can not only help states meet the EPA targets, but also **create local jobs that cannot be outsourced, while saving consumers money on their electricity bills.**[52]
- **Worker Training Programs.** The federal government already has a number of programs to support worker retraining and community development, all of which are currently funded and not reliant on further action from Congress. In particular, the Department of Agriculture's Rural Development program, the Department of Commerce's Economic Development Administration, the Department of Labor's Economic Training Administration, and the Appalachian Regional Commission all have programs in place to support workers and communities. By leveraging existing authority, the federal government can direct targeted resources to affected communities and help coal states diversify their economies. For example, the Obama Administration designated southeastern Kentucky as a federal Promise Zone[53] to focus on poverty alleviation by establishing a partnership between federal agencies and local institutions. Together, federal agencies should work with Congress to develop targeted legislation to address displaced workers in coal mining, coal fired power plants, and related industries. Numerous examples in recent history serve as a roadmap for successful worker retraining programs, including the Trade Adjustment Act and the Workforce Reinvestment Act. More recently, a bipartisan bill was introduced in the 113th Congress specifically directed at coal workers.[54]

---

[48] Gordon, M. 2013. Wyoming State Treasurer Annual Report for the Period July 1, 2012 through June 30, 2013. Online at http://treasurer.state.wy.us/pdf/annualweb2013.pdf.

[49] Bill Text, as passed, March 10, 2014: http://www.legis.state.wv.us/Bill_Status/Bills_history.cfm?input=461&year=2014&sessiontype=RS&btype=bill.

[50] See Lawrence Berkeley National Laboratory, http://emp.lbl.gov/rps.

[51] Heeter, J., G. Barbose, L. Bird, S. Weaver, F. Flores-Espino, K. Kuskova-Burns, and R. Wiser. 2014. A survey of state-level cost and benefit estimates of Renewable Portfolio Standards. Online at http://www.ourenergypolicy.org/wp-content/uploads/2014/06/nrel.pdf.

[52] Alliance to Save Energy. 2013. Energy Efficiency Resource Standard. Online at https://www.ase.org/sites/ase.org/files/resources/Media%20browser/eers_fact_sheet_9-13.pdf.

[53] http://www.nytimes.com/2014/01/10/us/politics/obama-announces-promise-zones-in-5-stricken-areas.html.

[54] http://blogs.rollcall.com/218/in-a-partisan-climate-two-lawmakers-try-to-talk-past-climate-change/.

With foresight and planning, states can develop implementation plans that lead to net job creation nationally. As the BlueGreen Alliance[55] emphasizes, it is **critical to provide direct support to workers and communities**—extending to ancillary and support sectors as well as the utility sector—if and when a power plant shuts down, by providing wages, benefits, training, education, and the recognition of basic workers' rights. **Communities will need resources to diversify their economies and create high-paying jobs that can match or exceed those that may have been lost.** The private sector, including utilities, and all levels of government must work in tandem with communities to make these transitions a success. Regulated entities should not be allowed to skirt commitments made to workers—as power plants and coal mines close or idle, owners should honor the commitments they made to workers, including pensions and health benefits.

Economic Diversification: A No-Regrets Strategy

Thankfully, West Virginia has many assets it can leverage to diversify its economy. But **we must let go of the idea that coal is all we've got**.

Communities all around Coal Country, from Beckley to Welch to Pikeville, are eager to have this conversation. They realize that times are changing, and they are calling for leadership. Over 200 people from a wide range of perspectives attended a forum UCS organized in September 2013 to talk about the state's Bright Future[56] (report attached). Participants pointed to the state's **top-notch work force**, natural resources, opportunities for **recreation and tourism, advanced manufacturing**, and more.

And the **conversations have continued**, from the ground up. Williamson is remaking itself as a healthy community focused on sustainability. Communities across West Virginia have been participating in a series of dialogues called "What's Next, West Virginia?"[57] A few state leaders are listening—as evidenced by the Shaping Our Appalachian Region (SOAR) initiative[58] in eastern Kentucky and the Southern Coalfields Organizing and Revitalizing the Economy (SCORE) initiative in southern West Virginia.

Even the President's proposed budget includes **significant investments in the Appalachian region** and recognizes that **coal miners "have kept the lights on in this nation for generations."** The proposal recognizes that there are a variety of existing federal programs that support workers. The initiative, the POWER Plus Plan, or Partnerships for Opportunity and Workforce and Economic Revitalization (POWER), is slated to build on existing programs during FY 2015 and expand in FY 2016. POWER Plus calls **for targeted funding for workforce development programs** at federal agencies, **strengthening the health care and pension plans that support over 100,000 retired miners**, releasing **$1 billion over 5 years for restoring abandoned mine land (AML) communities while promoting sustainable development,** and establishing **two new tax credits to spur deployment of carbon capture and sequestration (CCS) technology.**

---

[55] http://www.bluegreenalliance.org/news/publications/testimony-of-the-bluegreen-alliance-at-public-hearing-on-EPAs-clean-power-plan.

[56] UCS 2014. "A Bright Economic Future for the Mountain State." Online at www.ucsusa.org/wvbrightfuture

[57] http://whatsnextwv.org/

[58] http://www.soar-ky.org/

Together with federal policy makers, states should help ensure that economic diversification and resources for worker transition are an important part of their compliance plans. In doing so, together we can not only **establish a strong standard to protect the planet's climate**, but also **ensure that workers and communities have fresh economic opportunities**, as market forces drive a shift away from coal.

I do not accept that this is an "either-or" proposition.

Our children and our grandchildren will face the risks of a **vastly different climate caused by our failure to act to reduce emissions today**. My young niece, and maybe someday her children and grandchildren, will face an **uncertain future** if we don't get the second part right too.

It is much harder, but it is **imperative** that we do both.

OPEN ACCESS
IOP Publishing
Environmental Research Letters
Environ. Res. Lett. **9** (2014) 024006 (9pp)
doi:10.1088/1748-9326/9/2/024006

Economic impacts on West Virginia from projected future coal production and implications for policymakers

L J Richardson[1], R Cleetus[2], S Clemmer[2] and J Deyette[2]

[1] Union of Concerned Scientists, 1825 K St NW, Suite 800, Washington, DC, USA
[2] Union of Concerned Scientists, 2 Brattle Square, Cambridge, MA, USA

E-mail: JRichardson@ucsusa.org and RCleetus@ucsusa.org

Received 3 September 2013, revised 23 December 2013
Accepted for publication 3 January 2014
Published 18 February 2014

Abstract

Multiple economic and geologic factors are driving fundamental changes in the nation's energy system, weakening coal's dominance as a fuel for electricity generation, with significant implications for places like West Virginia that are heavily dependent on coal for economic activity. Some of these factors include low natural gas prices, rising labor costs and declining productivity, economic competition with other coal mining regions, environmental regulations to reduce pollution and safeguard public health, state energy efficiency and renewable electricity standards, falling costs of renewable energy resources like wind and solar, and the likely prospect of future limits on greenhouse gas emissions. This analysis uses an input–output model to examine the effects on West Virginia's economy from these multiple factors by exploring a range of scenarios for coal production through 2020. In addition to changes in the coal industry, hypothetical investments in additional sectors of the economy are considered as a way to gauge potential alternative economic opportunities. This paper offers recommendations to policymakers for alternative economic development strategies needed to create new jobs and diversify the state's economy, and highlights the importance of transition assistance at the federal level.

Keywords: economic impacts, coal, West Virginia, economic diversification

S Online supplementary data available from stacks.iop.org/ERL/9/024006/mmedia

1. Introduction

Economists have long studied the impacts of natural resource extraction on a country's economic growth and development. Booms in extractive industries have not always been associated with broad economic growth, a phenomenon called 'Dutch disease' (Corden and Neary 1982) or more broadly, the 'resource curse' (Sachs and Warner 1995, Gylfason 2004). Some governments have successfully avoided this fate, for example by investing oil revenues in pension funds, as Norway[3] and Bolivia[4] have done. Subnational governments have enacted similar policies, including Alaska's permanent fund and Wyoming's permanent mineral trust fund. As the United States and the world begin to curb greenhouse gas (GHG) emissions in response to the impacts of climate change, fossil fuels (coal in particular) are becoming less competitive when compared to other sources that result in little or no GHG emissions, like renewable energy. This analysis considers the possible economic impacts on the state of West Virginia, a longtime leading producer of coal, resulting from potentially declining future coal production and offers insights into the po-

---

[3] www.nbim.no/en/About-us/Government-Pension-Fund-Global/.

[4] http://academy.ssc.undp.org/GSSDAcademy/SIE/SIEV1CH2/SIEV1CH2P1.aspx.

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

1748-9326/14/024006+09$33.00

© 2014 IOP Publishing Ltd Printed in the UK

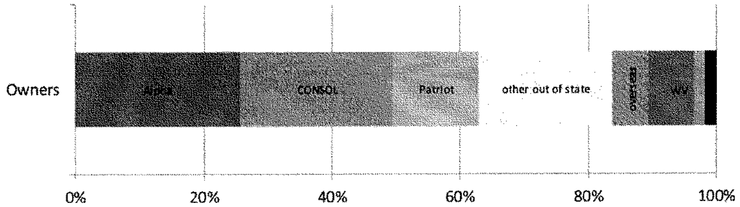


Figure 1. Three companies controlled more than 60% of coal produced in West Virginia in 2010, and all three were headquartered out-of-state. Less than 10% of coal produced in West Virginia (shown in blue) was controlled by in-state owners (the lighter shade represents entities with some in-state ownership). Gray portions represent out-of-state entities. The black sliver at the far right indicates the 1.7% of total production by owners with unknown location. See the supplemental materials (available at stacks.iop.org/ERL/9/024006/mmedia) for a list of the top 20 producers and detailed description.

tential for—and policy mechanisms to support—diversifying the state's economy.

After looking at coal ownership in West Virginia (section 2) and recent trends in the coal industry nationally and in West Virginia (section 3), this paper lays out a methodology (section 4) using coal projections from the Energy Information Administration (EIA) to analyze the range of possible future economic impacts (section 5) in the state through 2020. Finally, considering the potential for investments in other sectors of the state's economy (section 6), the paper offers recommendations for policymakers (section 7) and demonstrates the urgent need for economic diversification.

2. Ownership of West Virginia coal

Much of West Virginia's land and resources (and indeed, throughout Appalachia) are actually controlled by out-of-state owners. A seminal report dating back 30 years surveyed 80 counties in the Appalachian region and found that about 75% of surface lands and about 80% of mineral rights were controlled by out-of-county or out-of-state owners (Appalachian Land Ownership Task Force 1981). A recent report studied current surface ownership patterns in West Virginia and found that, of the top ten private landowners in the state, not a single one was headquartered in West Virginia (Spence *et al* 2013). In six counties, the top ten landowners own 50% or more of private lands.

Although the new study excludes the important question of mineral rights, absentee ownership of the state's natural resources persists. In 2010 West Virginia produced about 139 million short tons of coal from 244 active and producing mines that were ultimately owned by 91 different entities. The vast majority of coal production came from mines that were ultimately controlled by out-of-state interests, as shown in figure 1. The blue sections of the bar chart represent the fraction of coal produced (less than 10% of the total) owned by West Virginia proprietors or companies; the gray shaded sections, on the other hand, indicate the 89% of production controlled by out-of-state interests.

This structural reality implies that corporate profits from the coal industry generally leave the state. Therefore, aside from the local jobs created by the coal industry, the primary mechanism by which the state can benefit from this natural resource is through tax policy. In 2008, West Virginia's effective tax rate was 6.5% of the value of the coal removed from the ground (Boettner and O'Leary 2012). That figure includes various taxes and fees, but the primary one is the state severance tax, which remains at 5.0%, with exceptions for thin coal seams (O'Leary 2011).

3. Recent coal industry trends

Labor productivity, defined as the amount of coal mined per miner-hour worked, began to decline in all regions nationwide around 2000. The decline was most pronounced in Central Appalachia, falling by 45% between 2000 and 2010 (Energy Information Administration 2001, 2012a). At the same time, there have been reductions in reserve estimates of US coal fields and increased production costs, which also adversely affect the economics of coal mining (National Research Council 2007, Luppens *et al* 2008). For Central Appalachia in particular, the rapid decline in labor productivity indicates that the easiest to mine seams have been mined out (McIlmoil and Hansen 2010). However, an overall increase in coal production over the same period of time has outstripped the decline in labor productivity, resulting in an increase in coal mining employment. In 2010, about 86,000 coal miners[5] were employed in the United States, and about 25% of them worked in West Virginia (Energy Information Administration 2012a). The US Energy Information Administration (EIA) projects that this decline in labor productivity will continue in the foreseeable future (albeit more slowly than in the 2000s), leading to continued increases in the price of coal (Energy Information Administration 2013a).

Over the past few years, major changes have fundamentally shifted the economics of the electric power industry in the United States. Natural gas prices fell to historic lows due to widespread development of unconventional resources using horizontal drilling techniques and hydraulic fracturing. US electricity generation from wind and solar nearly quadrupled from 2007–2012, due to falling costs and supportive federal and state policies (Solar Energy Industries Association 2013, Wiser and Bolinger 2012). The PJM Interconnection Regional Transmission Organization (which includes West Virginia) recently held its capacity auction for 2016–2017, in which 10,000 MW of coal generation did not clear, in part due to importing low cost wind generation from the Midwest (PJM 2013). Environmental regulations focusing on reducing air pollution, protecting water, and lessening hazards from coal ash disposal have presented additional costs to coal-fired power plants, especially older, dirtier units (McIlmoil *et al* 2013). As concerns about the impacts of climate change grow, carbon intensive fuels such as coal will face additional costs to comply with future policies to cut greenhouse gas emissions. Taken together, these factors are putting many coal-fired power plants at an economic disadvantage (Fleischman *et al* 2013, Cleetus *et al* 2012, Freese *et al* 2011).

---

[5] EIA notes that employment figures include 'all employees engaged in production, preparation, processing, development, maintenance, repair shop, or yard work at mining operations, including office workers.'

Low natural gas prices, combined with a mild winter in 2012, led to an increase in electricity generation from natural gas and a decrease in generation from coal (SNL Energy 2012). In fact, in April 2012, coal's share of the electricity mix dropped below 40% for the first time since the 1970s; that month, coal and gas accounted for nearly the same level of generation (Energy Information Administration 2012c). Coal production fell sharply from 2011 to 2012: western production dropped 45% and Appalachian production fell 43% (Energy Information Administration 2013c). As a result, some coal mining operations in Appalachia have been idled (Ward 2012).

4. Methodology and assumptions

EIA coal data and county-level economic data, together with EIA projections for future coal production, are used in an input–output model to gauge changes in West Virginia's economy resulting from expected changes in coal production.

4.1. IMPLAN

This analysis uses the software package IMPLAN, a commercially available and commonly used input–output (I-O) modeling program (Lindall and Olson 1996) to analyze how changes in the coal industry impact West Virginia's economy. County-level 2010 IMPLAN data for all of West Virginia form the baseline state economy in 2010 and establish linkages among sectors. For our analysis, we split the state into northern and southern counties based on the type of coal mined (Northern or Central Appalachian). IMPLAN data are expressed in dollars, and the coal mining sector's industry output (or sales) is equivalent to the ***production value*** of the coal (i.e., price x production). Data collected by EIA on state coal production and regional coal prices are used to calculate the value of coal produced by northern and southern West Virginia in 2010. We updated the 2010 IMPLAN study area data for the coal mining sector with the EIA-derived production value. Projections for future coal production and prices come from various scenarios in EIA's Annual Energy Outlook (AEO) 2013 (Energy Information Administration 2013a). The projected production value of coal in 2020 represents the primary indicator used to conduct the economic analysis. For a given EIA scenario, the *difference* in coal production value between 2010 and 2020 is the input to the IMPLAN model. Details on the IMPLAN methodology can be found in the supplemental materials (available at stacks.iop.org/ERL/9/024006/mmedia).

4.2. Future coal scenarios

EIA projects a slight overall increase in US coal production through 2035, with important regional differences. The increase in production is driven primarily by Western and Interior coal. Within Appalachia, Central Appalachian production is in the midst of a steep decline, while Northern Appalachian production grows slightly (Energy Information Administration 2012b). The AEO 2013 Reference Case is based on all current federal, state, and local laws and policies in effect as of September 2012, as well as recent market trends, and is used as the baseline scenario for this analysis (Energy Information Administration 2013a). A number of other possible scenarios for future coal production, drawn from AEO 2013 side cases, are also considered in the analysis: two focusing on the production costs of coal (low coal cost and high coal cost); two focused on the availability of natural gas (low gas resource, which implies higher natural gas prices, and high gas resource, which implies lower natural gas prices); three that look at options for pricing greenhouse gas (GHG) emissions[6] (no GHG Concern, GHG10, GHG25); one that combines a carbon price with low natural gas prices (GHG10/low gas price); and one that considers a range of extended energy policies (extended policies). A list of the scenarios considered in this analysis is shown in table 1.

Of particular importance for coal production, the Reference Case includes the Mercury and Air Toxics Standard (MATS) and the Clean Air Interstate Rule (CAIR) (Energy Information Administration 2013b). MATS, finalized in December 2011, is assumed to be fully implemented by 2016, and sets limits on mercury, heavy metals, and acid gases from generators greater than 25 MW. CAIR is a cap and trade program that regulates SO_2 and NO_x emissions from fossil generators in 27 states and DC. Other proposed or pending regulations affecting coal, including the stream buffer rule and coal waste regulations, are not considered by the AEO 2013 but could have significant implications for coal production, especially for Central Appalachia (McIlmoil *et al* 2013). Because the AEO side cases do not explicitly consider the impacts of different environmental regulations, and because it is difficult to compare AEO reference cases from previous years, this analysis does not quantify the relative impacts of environmental regulations on West Virginia's economy.

5. Results

Scenarios represent a range of possible futures for coal production through 2020. Figure 2 illustrates projected coal production for the reference case and four selected scenarios, showing

---

[6] EIA considered GHG prices of $10/ton and $25/ton, but notably, more recent estimates of the social cost of carbon are higher (Interagency Working Group on Social Cost of Carbon 2013).

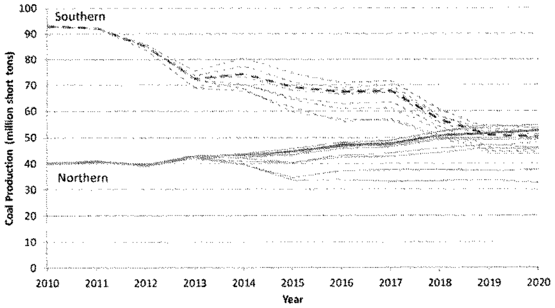


Figure 2. All scenarios considered for West Virginia coal production through 2020. Northern West Virginia production (blue, solid curves) is slightly increasing over this period; southern West Virginia (red, dashed curves) is in the midst of a steep decline in production. Reference cases for both are shown in bold. Details on all scenarios can be found in the supplemental materials (available at stacks.iop.org/ERL/9/024006/mmedia).

Table 1. Description of scenarios used in the analysis (Energy Information Administration 2013b).

Scenario	Assumptions
Reference	The 'business as usual' case. Includes all federal, state, and local laws in effect as of September 2012. Assumes real GDP grows at an average annual rate of 2.5% from 2011 to 2040.
Low coal cost	Productivity growth rates for coal mining in all regions are ~2.5% per year higher than the Ref case. Coal mining wages, mine equipment, and coal transport rates are all lower than the Ref case, down to ~25% below the Ref case in 2040.
High coal cost	Productivity growth rates for coal mining in all regions are ~2.5% per year lower than the Ref case. Coal mining wages, mine equipment, and coal transport rates are all higher than the Ref case, up to 25% to 32% above the Ref case in 2040.
Low gas resource	Estimated Ultimate Recovery (EUR) per shale gas, tight gas, and tight oil well is 50% lower than in the Ref case.
High gas resource	EUR per well is 100% higher than in the Ref case.
No GHG concern	No GHG policy is enacted, and market investment decisions are not altered in anticipation of such a policy. This removes the 3% cost multiplier for coal plants assumed in the Ref case.
GHG$10	Applies an economy-wide price for CO2 emissions, starting at $10/ton in 2014 and rising by 5% per year through 2040.
GHG$10 and low natural gas prices	Combines the GHG$10 and high gas resource side cases.
GHG$25	Applies an economy-wide price for CO2 emissions, starting at $25/ton in 2014 and rising by 5% per year through 2040.
Extended policies	Extends all existing energy policies and legislation with sunset provisions, as well as an extension and increase in capacity cap of the Investment Tax Credit. Also assumes additional rounds of efficiency standards, building codes, and fuel economy standards.

both northern and southern West Virginia. In general, northern counties can expect a slight increase in coal production over the next decade, except in extremely unfavorable conditions (like the high GHG price scenario shown in figure 2). Southern counties, meanwhile, face a dramatic drop in coal production; even in the reference case, production from southern counties falls from 93 million short tons in 2010 to 50 million short tons in 2020, a decline of 43%. Details on all scenarios, along with trends in coal production, production value, and mining employment, can be found in the supplemental materials (available at stacks.iop.org/ERL/9/024006/mmedia).

Armed with the difference in coal production value for each scenario, IMPLAN is used to gauge the range of potential economic impacts on the state in 2020. Total changes in employment and in total economic activity are tabulated from the IMPLAN run of each scenario. These impacts statewide are plotted in figure 3. Importantly, the results are presented as the difference between the impact in a given scenario and that of the reference case in 2020. For example, in 2020, in the low coal cost case, there are about 6000 fewer jobs economy-wide than in the reference case (figure 3(a)) and just over $1.5 billion less in total economic output than in the reference

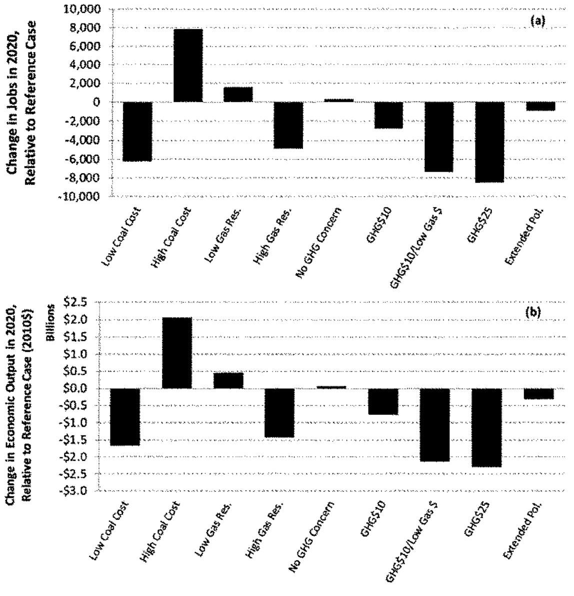


Figure 3. Comparison of IMPLAN model results for each scenario, indicating (a) the change in employment and (b) the change in total economic activity from 2010 to 2020. These results are expressed as the difference between the change projected in each scenario and the change expected in the reference case in 2020. That is, these charts show the projected changes with respect to what EIA expects for business as usual in 2020.

case (figure 3(b)). For reference, West Virginia's gross state product (GSP) was approximately $62.7 billion in 2010. The magnitude of the changes projected in each scenario can be found in the supplemental materials (available at stacks.iop.org/ERL/9/024006/mmedia).

Six of the nine scenarios indicate reduced economic activity statewide relative to the reference case (figure 3). Only three scenarios project increased economic activity in the state; in the high coal cost case, additional labor, goods, and services are needed to maintain production levels, resulting in increased economic activity. When natural gas prices are high (low gas resource), coal production increases, boosting the state's economy. No GHG concern results in very slight increases in the state's economic activity.

However, the total statewide impacts hide important differences between the northern and southern counties (figure 4). The cost of coal production has a significant impact on total jobs and economic activity in southern counties, compared to the reference case. Northern counties face more dramatic decreases—relative to the reference case—in jobs and economic activity for cases that consider a price on GHG emissions. That is not to say that southern counties fare better; on the contrary, as noted in figure 2, southern West Virginia is already in the midst of a steep decline in coal production.

To gain insight into the price competition between coal and natural gas, the low and high gas resource cases are useful. Recall that the low gas resource case implies higher prices for natural gas, and conversely for the high gas resource case (table 1). As expected, low prices for natural gas, which result in more displacement of coal with natural gas to generate electricity, have a severely negative impact on the state's economy as a whole. The trend holds for northern and southern counties separately (figure 4).

Scenarios that assume a future cost for the emission of GHGs have a strongly negative effect on the state's economy, unless the state shifts away from its economic dependence on coal and invests in alternatives. The $25/ton price beginning in 2014 has the most negative impacts on the statewide economy of any scenario. The $10/ton GHG price combined with the high gas resource case produces nearly the same level of negative impacts. Given the growing concern over the impacts of climate change, the implementation of policies to price carbon emissions seems to be inevitable. These results emphasize the need to diversify West Virginia's economy to help mitigate the potential negative economic impacts of future

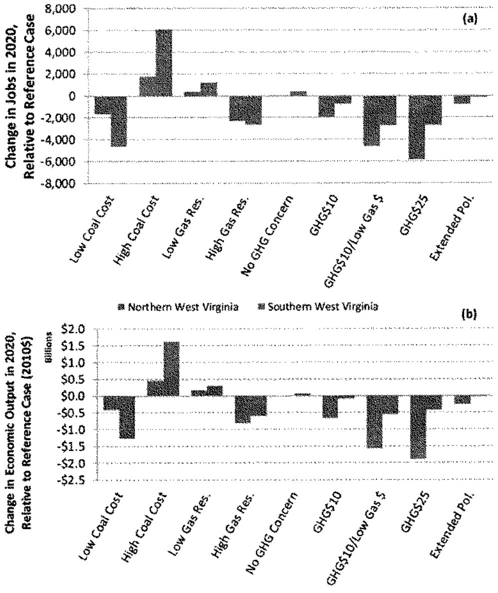


Figure 4. These charts are comparable to those of figure 3 but explicitly show the differences between northern and southern counties. Note again that these results are expressed as the difference between the change projected in each scenario and the change expected in the reference case in 2020.

climate policy. Notably, the low coal cost case produces a more severe impact on the southern counties than even the highest GHG price.

6. The potential for diversification

6.1. Policy solutions

The economic impacts from projected changes in coal production through 2020 demonstrate the critical need to invest in alternative forms of economic development in West Virginia. Some state leaders are actively working on policies to help the state diversify its economy. Senate President Jeff Kessler introduced a bill in the 2013 legislative session that would have established the West Virginia Future Fund using a portion of severance taxes from natural gas drilling (Kessler 2013). He recently led a delegation to North Dakota to study what that state is doing to take advantage of the recent boom in natural gas drilling (Gutman 2013). The revenue stream generated from the fund would depend on its structure. Assuming it allowed annual withdrawals of 5%, one analysis suggests it could generate additional annual revenue of approximately $40 million in 2020 (Boettner 2013).

Yearly withdrawals could be used to invest in West Virginia communities and counties, particularly in those most affected by extractive industries, and investments could include infrastructure projects, education, early childhood development, and even transition assistance as coal mining declines (Boettner *et al* 2012). Although the Future Fund as proposed would be funded from a portion of severance taxes from natural gas drilling, the idea of a slight (1%) increase in the coal severance tax has also been suggested (Boettner *et al* 2012, O'Leary 2011). Recent polling shows extremely strong support by West Virginians for the Future Fund concept, and even for the idea of raising taxes on the coal industry by 1%, if the revenues were used to support infrastructure and economic development (Richardson 2013, Lake Research Partners 2013, Ward 2013).

6.2. Alternative economic sectors

Since the structure of the ultimate policy enacted (if any) is not known, this exercise considers a hypothetical investment of $1 million dollars in 2020 in a variety of different sectors of the state's economy. This allows a comparison of the job creation potential of different sectors on a per-million-dollars invested basis. Similar to the coal scenario analysis, the investment is

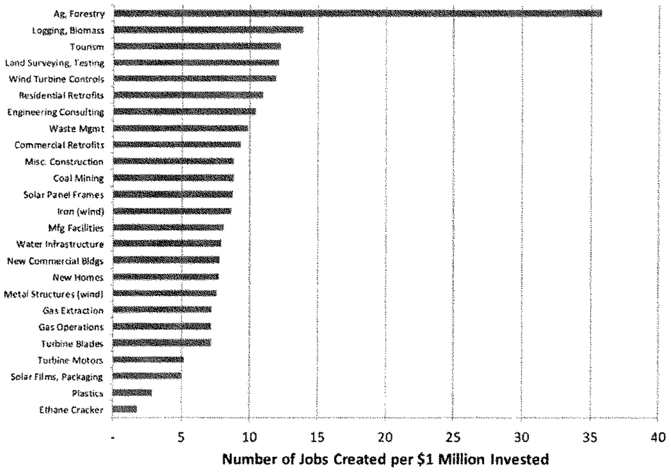


Figure 5. Total number of jobs created in a number of different sectors, per $1 million in increased sales.

represented in IMPLAN as an increase of $1 million in industry output for a given sector. Industrial sectors were chosen to reflect potential growth areas in the coming decade. Candidate sectors were derived from the state's existing economy in 2010 and include only those that had a minimum of 100 existing jobs in both northern and southern counties. That is an important criterion, because the idea was not to model the creation of new industries within the state, but rather to gauge the potential for job growth from retooling or expanding current industries. Potential sectors were drawn in part from a list of industrial sectors that could include green jobs (Bureau of Labor Statistics 2013b), but also included other existing and primary economic sectors in West Virginia. A broad range of sectors were included in the analysis, including renewable energy, natural gas, energy efficiency, agriculture, recycling, and reclamation of abandoned mine lands; details on the sectors and potential jobs created can be found in the supplemental materials (available at stacks.iop.org/ERL/9/024006/mmedia).

Potential sectors that could support the wind industry supply chain (Sterzinger and Svrcek 2004) and that had existing jobs in West Virginia include production of turbine controls, iron, metal structures, and turbine blades and motors. Similarly, for the solar industry supply chain (Sterzinger and Svrcek 2005), West Virginia companies could potentially support the production of solar films and packaging, encapsulants, and solar panel frames. The sector with the greatest job multiplier in the state was agriculture and forestry, which could include activities such as organic farming and post mining land reclamation (figure 4). Logging was a distant second, and notably could include the production of wood chips for biomass power plants or co-firing in coal plants. Energy efficiency efforts could fall under a number of construction related sectors, including retrofitting existing residential buildings and commercial buildings, construction of manufacturing facilities, and construction of new homes and commercial buildings. Coal mining is shown for comparison, and it falls near the middle of the list; ten sectors have higher job creation potential than that of mining.

7. Conclusions and recommendations

This analysis underscores the fact that West Virginia's economy is vulnerable to changes in coal production, as is well documented for economies based heavily on resource extraction and subject to boom-bust cycles (O'Leary and Boettner 2011, Sachs and Warner 1995). Coal mining employment declined steadily over the last half of the 20th century, mostly the result of increased mechanization (see the supplemental materials available at stacks.iop.org/ERL/9/024006/mmedia). Furthermore, the geologic and economic forces at work in West Virginia (especially in southern counties) are not likely to be offset by policy decisions of any particular legislative body or executive agency. Yet there is still much the state can do to address the uncertainty in the coal mining industry and the potential impacts on the state's economy. This analysis suggests that investing in other sectors of the economy can provide a cushion against future shocks resulting from changes in the coal industry. Recommendations to state leaders and policy makers are:

- West Virginia should focus efforts on diversifying its economy, particularly in southern counties and communities where the coal industry drives the local economy. The state budget could include specific support for economic diversification to support new and existing small scale efforts in West Virginia communities.
- Instead of fighting EPA's statutory obligations to reduce pollution from power plants, West Virginia leaders could focus instead on securing federal assistance to help workers hardest hit by the transition away from coal, and on ensuring that federal money is used effectively to help communities diversify their local economies.
- Given that West Virginians strongly support economic diversification (Richardson 2013, Lake Research Partners 2013, Ward 2013), funded by taxes on extractive industries like coal and natural gas, state leaders could establish the Future Fund to ensure that revenue is made available annually and immediately to support economic diversification and workforce development in communities.
- West Virginia's challenges extend well beyond the changes happening in the coal industry, and touch on a number of other issues, including low workforce participation, an aging population, lack of broadband access, infrastructure needs, poor health outcomes, drug addiction, and education; policy makers must take a holistic view of overcoming these challenges.

As the last few years have shown, big changes are happening in the energy sector in the nation as a whole. With leadership and vision, West Virginia can reinvent itself as more than just an energy state and ensure a bright future for future generations.

Acknowledgments

This work was supported by the Union of Concerned Scientists and its Kendall Science Fellowship program.

References

Appalachian Land Ownership Task Force 1981 *Land Ownership Patterns and Their Impacts on Appalachian Communities: A Survey of 80 Counties* (Washington, DC: Appalachian State University and Highlander Research and Education Center)

Boettner T 2013 private communication

Boettner T, Kriesky J, McIlmoil R and Paulhus E 2012 *Creating An Economic Diversification Trust Fund: Turning Nonrenewable Natural Resources into Sustainable Wealth for West Virginia* (Charleston, WV: West Virginia Center on Budget and Policy) Online: www.wvpolicy.org/downloads/WVEconomicDiversificationTrustFundRpt013012.pdf

Boettner T and O'Leary S 2012 *Major Yax Responsibilities of Coal and Natural Gas Producers in Wyoming and West Virginia* (Charleston, WV: West Virginia Center on Budget and Policy) Online: www.wvpolicy.org/downloads/TaxResponsibilities030212.pdf

Cleetus R, Clemmer S, Davis E, Deyette J, Downing J and Frenkel S 2012 *Ripe for Retirement: The Case for Closing America's Costliest Coal Plants* (Cambridge, MA: Union of Concerned Scientists) Online: www.ucsusa.org/assets/documents/clean_energy/Ripe-for-Retirement-Full-Report.pdf

Corden W M and Neary J P 1982 Booming sector and de-industrialisation in a small open economy *Econ. J.* **92** 825

Energy Information Administration 2001 *Annual Coal Report 2001* (Washington, DC: US Department of Energy) Online: www.eia.gov/coal/annual/archive/05842001.pdf

Energy Information Administration 2012a *Annual Coal Report 2011* (Washington, DC: US Department of Energy) Online: www.eia.gov/coal/annual/pdf/acr.pdf

Energy Information Administration 2012b *Assumptions to the Annual Energy Outlook 2012: Coal Market Module* (Washington, DC: US Department of Energy)

Energy Information Administration 2012c Monthly coal- and natural gas-fired generation equal for first time in April 2012 *Today Energy* Online: www.eia.gov/todayinenergy/detail.cfm?id=6990#

Energy Information Administration 2013a *Annual Energy Outlook 2013* (Washington, DC: US Department of Energy) Online: www.eia.gov/forecasts/aeo/pdf/0383%282013%29.pdf

Energy Information Administration 2013b *Assumptions to The AEO 2013* (Washington, DC: US Department of Energy) Online: http://nuclear.com/archive/2012/12/05/ML12339A605.pdf

Energy Information Administration 2013c *Short-Term Energy Outlook—US Energy Information Administration (EIA)* Online: www.eia.gov/forecasts/steo/report/coal.cfm

Fleischman L, Cleetus R, Deyette J, Clemmer S and Frenkel S 2013 Ripe for retirement: an economic analysis of the U.S. coal fleet *Electr. J.* **26** 51

Freese B, Clemmer S, Martinez C and Nogee A 2011 *A Risky Proposition: The Financial Hazards of New Investments in Coal Plants* (Cambridge, MA: Union of Concerned Scientists)

Gutman D 2013 18 W.Va. legislators off to study North Dakota's Legacy Fund *Charlest. Gaz.* Online: www.wvgazette.com/News/201307260138

Gylfason T 2004 *Natural Resources and Economic Growth: From Dependence to Diversification* (Berlin: Springer) Online: http://link.springer.com/content/pdf/10.1007/3-540-31183-1_10.pdf

Interagency Working Group on Social Cost of Carbon 2013 *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* Online: www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf

Kessler J 2013 *SB 167 Text* Online: www.legis.state.wv.us/Bill_Status/bills_text.cfm?billdoc=SB167%20SUB1.htm&yr=2013&sesstype=RS&i=167

Lake Research Partners 2013 Support for Expanding West Virginia's Energy Economy and West Virginia Future Fund. Online: www.ucsusa.org/assets/documents/global_warming/Lake-Research-Partners-Poll-Results-June-2013-Topline-Memo.pdf

Lindall S A and Olson D C 1996 *The IMPLAN Input–Output System* (Stillwater, MN: MIG, Inc.)

Luppens J A, Scott D C, Haacke J E, Osmonson L M, Rohrbacher T J and Ellis M S 2008 *Assessment of Coal Geology, Resources, and Reserves in the Gillette Coalfield, Powder River Basin, Wyoming* (Reston, VA: US Geological Survey) Online: http://pubs.usgs.gov/of/2008/1202/pdf/ofr2008-1202.pdf

McIlmoil R and Hansen E 2010 *The Decline of Central Appalachian Coal and the Need for Economic Diversification* Downstream Strategies, Online: www.downstreamstrategies.com/documents/reports_publication/DownstreamStrategies-DeclineOfCentralAppalachianCoal-FINAL-1-19-10.pdf

McIlmoil R, Hansen E, Askins N and Betcher M 2013 *The Continuing Decline in Demand for Central Appalachian Coal: Market and Regulatory Influences* (Morgantown, WV: Downstream Strategies) Online: www.downstreamstrategies.com/documents/reports_publication/the-continuing-decline-in-demand-for-capp-coal.pdf

National Research Council 2007 *Coal: Research and Development to Support National Energy Policy* (Washington, DC: National Academies Press)

O'Leary S 2011 *Investing in the Future: Making the Severance Tax Stronger for West Virginia* (Charleston, WV: West Virginia Center on Budget and Policy) Online: www.wvpolicy.org/downloads/SeveranceTax022812.pdf

O'Leary S and Boettner T 2011 *Booms and Busts: The Impact of West Virginia's Energy Economy* (Charleston, WV: West Virginia Center on Budget and Policy)

PJM 2013 *2016/2017 RPM Base Residential Auction Results* Online: www.pjm.com/~/media/markets-ops/rpm/rpm-auction-info/2016-2017-base-residual-auction-report.ashx

Richardson J 2013 Surprisingly, West Virginians support raising taxes on the coal industry–even in coal country *The Equation* Online: http://blog.ucsusa.org/surprisingly-west-virginians-support-raising-taxes-on-the-coal-industry-even-in-coal-country-172

Sachs J D and Warner A M 1995 *Natural Resource Abundance and Economic Growth* National Bureau of Economic Research

Solar Energy Industries Association 2013 US Solar Market Insight Report Q1 2013. Online: www.seia.org/sites/default/files/4Y8cIWF6ps2013q1SMIES.pdf?key=57789436

Spence B, Kunkel C, Schewel E, Boettner T and Martin L 2013 *Who Owns West Virginia* (Charleston, WV: West Virginia Center on Budget and Policy and American Friends Service Committee) Online: www.wvpolicy.org/who-owns-west-virginia-in-the-21st-century-2

Sterzinger G and Svrcek M 2004 *Wind Turbine Development: Location of Manufacturing Activity* Renewable Energy Policy Project

Sterzinger G and Svrcek M 2005 *Solar PV Development: Location of Economic Activity* Renewable Energy Policy Project

Ward K Jr 2012 New data reflects coal layoffs, but no job collapse *Charlest. Gaz*. Online: www.wvgazette.com/News/201208080279?build=yes

Ward K Jr 2013 Most in W.Va. want higher coal tax, poll shows *Charlest. Gaz*. Online: www.wvgazette.com/News/MiningtheMountains/201306270095

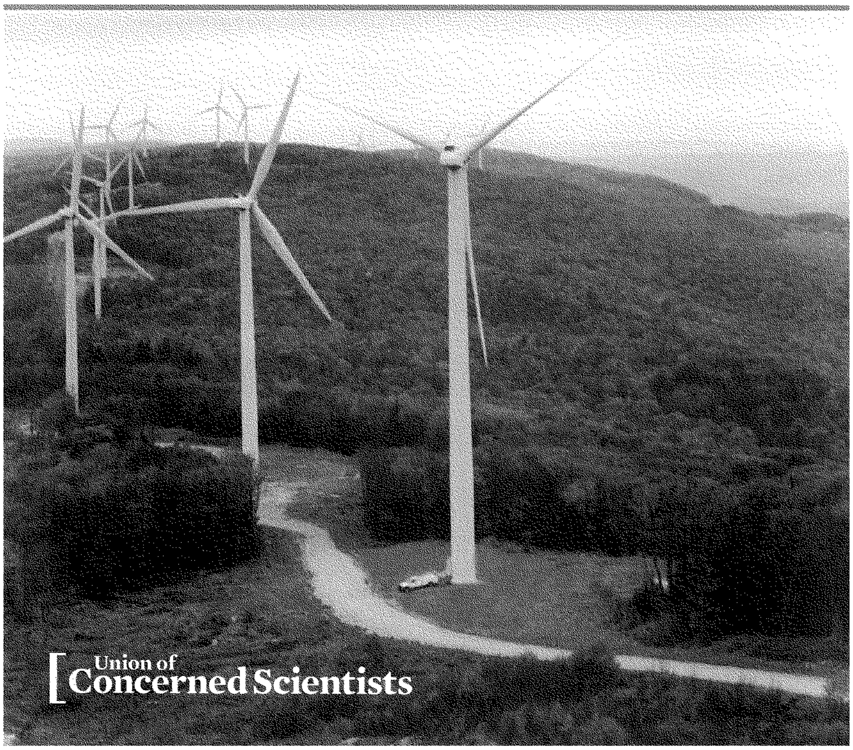
Wiser R and Bolinger M 2012 *2011 Wind Technologies Market Report* (Washington, DC: US Department of Energy, Office of Energy Efficiency and Renewable Energy) Online: http://escholarship.org/uc/item/1vd1s6gf.pdf

A Bright Economic Future for the Mountain State

Economic diversification
in West Virginia

Jeremy Richardson

November 2013



Union of
Concerned Scientists

The transition to a clean energy economy is a frightening prospect for states and communities firmly rooted in the fossil fuel economy. Partly as a result, debate about our nation's energy policy has become toxic in West Virginia and the broader Appalachian region.

Discussions of environmental concerns—whether related to mountaintop removal, hydraulic fracturing, or climate change—tend to send people to opposing corners, with neither side willing to budge, or even to engage in civil discourse. And parties too often focus on the tension between job growth and environmental protection, assuming that the two are mutually exclusive.

As the son and brother of West Virginia coal miners, I see a desperate need and a timely opportunity for a more constructive conversation. This report summarizes a meeting that represents the culmination of a 21-month research project I completed for the Union of Concerned Scientists through its Kendall Science Fellowship. In my research, I studied the cultural and historical importance of coal to West Virginia, and analyzed the economic importance of future coal production for the state and the potential to diversify its economy.

Even in the heart of coal country, people recognize that things are changing. I believe that by concentrating on the opportunities that lie ahead—and by directly addressing the challenges we face—we can ensure a vibrant future for generations of West Virginians to come.

Jeremy Richardson
Senior energy analyst
Union of Concerned Scientists

> ***If coal is King, he hasn't taken very good care of his subjects.***
>
> *—Lieutenant Governor and Senate President Jeff Kessler*

Context

Coal has been an important part of West Virginia's economy almost since it achieved statehood in 1863. Talk of the future of coal evokes strong emotions: state residents identify with coal and take pride in its history. As West Virginia celebrates its 150th birthday, however, coal faces enormous challenges, and its importance in the state's economy is on the decline.

Low natural gas prices and slow growth in demand for electricity have led to a drop in coal consumption nationally—with significant implications for West Virginia's coal industry. Shrinking reserves are also making the coal in Central Appalachia more difficult to mine, and therefore more costly. Southern Company, which operates 46 gigawatts of generating capacity in four southeastern states, now sources about a fifth of its coal from Central Appalachia. Following electricity industry trends, however, it plans to all but remove the region's coal from its fuel mix because it is too expensive. The coal industry has responded to these changes by idling coal mines across the region and laying off mine workers.

To explore the potential to diversify the state's economy—and celebrate local successes in pursuing new paths to economic development—the Union of Concerned Scientists (UCS) partnered with the West Virginia Center on Budget and Policy and the West Virginia Community Development Hub to convene "A Bright Economic Future for the Mountain State." The forum took place on September 3 and 4, 2013, at the Clay Center for the Arts and Sciences in Charleston, West Virginia.

The forum posed a critical question: "What do we want West Virginia to be like in 30 years?" This focus allowed speakers and other participants to consider what the state could offer to ensure that their kids and grandkids can work and live in the places where they grow up. The question also allowed participants to break out of the tired jobs-versus-the-environment frame that dominates most conversations about the state's future.

Cover photo: © Todd Spink/NREL

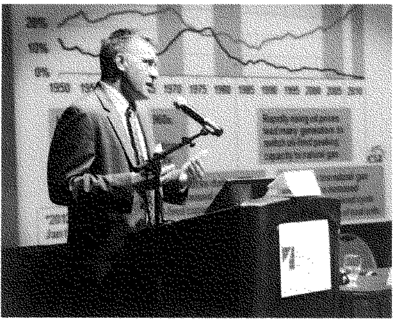
Attendees at the start of Wednesday morning's program.

Stacy Jarrell

Some 200 people—representing an unusually diverse mix of perspectives—attended the forum's keynote addresses, three panel discussions, and documentary screening. Speakers and other attendees included business owners, energy industry executives, state and local officials, members of faith communities, labor representatives, academics, environmentalists, and individuals from nonprofits spearheading local economic development. Reporters also attended, and media interest in the event was strong. (For the forum agenda, a list of participants, and speaker biographies, see Appendices A, B, and C, respectively. For excerpts from media coverage of the event, see Appendix D.)

This report highlights the main themes emerging from the Bright Future forum. These include:

- West Virginia must have a vision to carry it through the challenge of fostering a future that will inevitably look different from the past.
- Regional and local leaders are beginning to spur and create new businesses and jobs, but they desperately need state leadership to ease the transition to a more diversified economy.
- West Virginia has tremendous assets that it can mobilize in building such an economy.
- The state also faces multiple challenges that it must address in a comprehensive way.



Jeremy Richardson of UCS explains the importance of diversifying West Virginia's economy.

Stacy Jarrell

In opening the conference, Jeremy Richardson, now a UCS senior energy analyst, pointed out that the state's "current path is not sustainable," given the decline in coal production in southern West Virginia. Using projections from the federal Energy Information Administration, he showed that the coal industry is likely to continue to shrink as a share of the state's economy, underscoring the critical need for economic diversification.

However, most events designed to explore West Virginia's future are one-sided, attracting either environmental activists or coal supporters, but rarely both. The Bright Future forum sought to find common ground. Toward that end, organizers asked keynote speakers and panelists to cite model programs and specific solutions in West Virginia and elsewhere that suggest a path toward a sustainable economic future.

Addressing an evening reception, West Virginia Secretary of State Natalie Tennant noted the potential for renewable energy jobs in the state, and Lieutenant Governor and Senate President Jeff Kessler touted his bill for diversifying the state's economy. Unable to attend at the last minute, U.S. Senator Jay Rockefeller, in his prepared remarks (see Appendix E), stressed the importance of innovation as a driver of the West Virginia economy, and highlighted the role of the 2011 federal America COMPETES Act in strengthening education in science and math.

> ***Regional and local leaders are beginning to spur and create new businesses and jobs, but they desperately need state leadership to ease the transition to a more diversified economy.***

> ***We have to understand that the future will not look like the past.***
>
> *—Matt Ballard, president, Charleston Area Alliance*

Vision

In a keynote address, Tom Heywood—a prominent Charleston lawyer who serves as managing partner at Bowles Rice, a regional law firm—suggested that West Virginia "is entering its golden age." Supporting his positive vision, Heywood cited the state's lower-than-average unemployment rate (6.3 percent, versus 7.3 percent nationally, as of August 2013); large "rainy day" fund; recent efforts to strengthen education; infrastructure improvements such as the building of roads, bridges, and schools; growing philanthropic support; and extensive natural resources.

To fulfill his vision for West Virginia, Heywood urged forum participants to "imagine a future state and work backwards," as opposed to asking, "What do we have and what can we do with it?" We must, he said, "create the future from the future." Acknowledging West Virginia's challenges, he nevertheless urged leaders not to accept being "second best," but to project the idea that West Virginia is "the best state in the nation already." This positive spirit resonated throughout the forum.

All four members of the first panel noted that visions for the future of West Virginia must chart a new course. For example, referring to the state's coal industry, Matt Ballard, president and CEO of the Charleston Area Alliance—the largest chamber of commerce in the state—noted that some people want West Virginia to stay the same, and called that attitude a "hurdle that needs to be overcome. . . . We have to understand that the future will not look the same as the past."

Former Congressman Alan Mollohan stressed the need for economic diversification. Although "most politicians focus on extraction and policies that support them," promoting other sectors of the economy is critical, he said. "West Virginia's coal, timber, and gas resources aren't going anywhere, but with diversification we can create a more flexible, resilient, and vibrant economy." Public-private partnerships can help promote such diversification, according to Mollohan.

Ballard offered an example of such a partnership: the alliance between the state and landowners that created the Hatfield-McCoy Trail System for off-road vehicles. This 600-mile-plus system—one of the world's largest—has inspired people who never thought they would own their own business to become entrepreneurs, noted Ballard. The result is numerous new outfitting shops, ATV rental and repair shops, and restaurants in southern West Virginia.

Stressing the importance of small businesses to the state's economy, Ballard called for a cultural shift toward entrepreneurialism, noting that, "No one in my public education ever told me that I could run my own business; that needs to change." Indeed, 94 percent of West Virginia businesses are already considered small, based on the federal government's definition, said Commerce Secretary Keith Burdette during a later panel, and many of those businesses make components of everyday items many West Virginians use.

Stacy Jarrell

Beth Vorhees, host of West Virginia Morning *on West Virginia Public Broadcasting, moderates the first panel discussion with (left to right) Alan Mollohan, Scott Rotruck, Anne Barth, and Matt Ballard.*

Panelist Scott Rotruck, a retired energy industry executive, affirmed that West Virginia is an energy state, but urged forum participants to "think about energy in new ways." In response to a question from the audience, Rotruck affirmed that the state will be mining coal in 30 years "but to a lesser degree," and highlighted the opportunity to encourage energy efficiency, calling it a "no regrets option." Kent Spellman, executive director of the West Virginia Community Development Hub, also pointed to greater energy efficiency as a win-win, even for the energy sector, and emphasized the importance of diversifying the state's energy mix.

The state needs a culture change regarding the value of energy efficiency, agreed Ballard. "Some people believe that leaving the lights on burns more coal and is therefore better for the economy. That, of course, is not the case," he said, because making homes and businesses more energy-efficient creates new jobs that cannot be outsourced. At the same time, West Virginia must realize that "investment, innovation, and economic development are long-term propositions" requiring "discipline and patience."

Panelist Anne Barth, executive director of TechConnect WV—a coalition of industry, the public sector, and higher education that aims to foster economic development—also heralded the "innovation economy" as "the driving force of new, high-quality jobs in West Virginia" over the next 30 years. "The enemy is the status quo," she said. Efforts to turn innovation into new enterprises in four key industries—advanced energy, chemicals, biotechnology, and biometrics—have already sparked recent growth in the state economy and can drive further growth, she said.

Reverend Jeff Allen, head of the West Virginia Council of Churches and a panelist, asked, "Who gets to decide what kind of economy we are going to have in West Virginia?" and urged more inclusiveness. Dialogues in communities across the state are helping residents better understand the state's economic challenges, and potential responses and next steps. However, we "must find a way to cross the boundary from the old to the new West Virginia so that no one is left behind," Allen cautioned.

Toward that end, the Hub concentrates wealth creation, not just job creation, in rural communities, according to Spellman. He argued that businesses should think of themselves as a "social enterprise," and that, "Their business needs to benefit the community and the community needs to benefit from that business, just as the business needs to do well." Discussions of economic diversification, he argued, "need to be taken down to where the people are."

> ***We can't change the past, but we can invest in the future.***
>
> *—Ted Boettner, executive director, West Virginia Center on Budget and Policy*

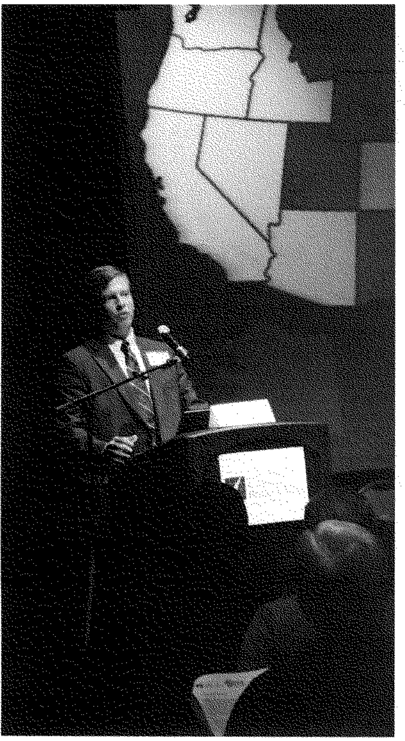
Communities Leading, State Absent

The Bright Future forum sought to highlight success stories from communities already working to diversify their economies beyond traditional extractive industries. Several speakers highlighted examples from the tourism sector. Spellman urged participants to see tourism not just as a way to bring people to the state to spend money, but rather as a pathway for attracting and supporting entrepreneurs: "Tourism is the best marketing and recruiting tool we have."

Panelist Matt Wender, president of the Fayette County Commission in south-central West Virginia, described the county's 40-year history of using land-use planning and zoning to foster economic growth. That planning process helped gain national park status for some 70,000 acres in the county, setting the stage for a booming tourism industry and the creation of a Boy Scouts retreat center.

Panelist Chris Yura, founder and president of SustainU Clothing, based in Morgantown, relied in part on a business incubator program at West Virginia University to develop his business, which makes clothing from 100 percent recycled plastics and cotton. The thriving company, now with 20 full-time employees, obtains its material and manufactures its products in the region.

Panelist Kristen Barker, president of the Cincinnati Union Co-op Initiative, described a job creation model now being tested in Cincinnati and 10 other cities across the United States. The approach is based on Spain's Mondragon cooperative. Now that country's seventh-largest corporation, Mondragon has built a globally competitive business based on workplace democracy, personal and professional development for employees, and efforts to strengthen communities and the environment.



Stacy Jarrell

Ted Boettner, executive director of the West Virginia Center on Budget and Policy, points out that several other states rich in natural resources have created policies similar to the proposed West Virginia Future Fund.

The Cincinnati initiative has drawn on that model to launch a worker-owned food hub that connects local farmers with local consumers. Spellman pointed out that if West Virginia increased production of the food consumed in the state by even a small fraction, the additional economic impact would be significant. In his research on alternatives for the state's economy, Richardson found strong job creation potential in both the agriculture and tourism industries.

Although local leaders are taking innovative paths to strengthen local and regional economies, the forum revealed a critical need for state leadership and policies to help diversify the economy. Kessler was the main sponsor of a bill in the last legislative session to create one such policy: the West Virginia Future Fund.

To supply the fund, the state would invest a fraction of taxes on the production of natural gas above a baseline level. After 20 years, the state would begin to use the returns to support infrastructure and education designed to diversify the West Virginia economy. Other resource-rich states such as Wyoming and North Dakota have used royalties on mineral lands, severance taxes on the production of coal and natural gas, or both to create such trust funds.

Ted Boettner, executive director of the West Virginia Center on Budget and Policy, noted that a trust fund would enable state government to turn finite natural resources into an infinite source of revenue. If West Virginia had established a future fund based on a 1 percent severance tax on coal starting in 1970, "we would have close to $8 billion in a trust fund today," he pointed out. "We can't change the past, but we can invest in the future." However, the present proposal is too vague, he contends, and policy makers should begin to draw on the fund five years after its inception to support West Virginia's future.

A poll of likely West Virginia voters commissioned by Richardson showed that nearly 70 percent support the creation of such a fund. By a 50 percent margin, respondents also support increasing severance taxes on coal slightly and using the revenues for similar purposes. Several participants remarked that this finding was unsurprising: of course West Virginians believe that coal companies should invest in the communities where they operate. Kessler plans to reintroduce the bill in the upcoming legislative session.

> ***There are none better than the workers in West Virginia.***
>
> *—Kenny Perdue, president, West Virginia AFL-CIO*

West Virginia's Assets

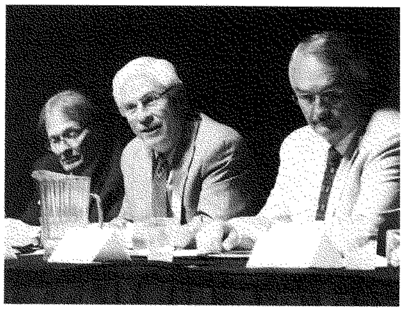
Forum speakers and panelists highlighted West Virginia's assets and how they might inform the vision of the state's future. Those assets tended to fall into three categories: natural resources, people, and place.

Speakers highlighted the state's extensive natural gas deposits, and enthusiastically embraced the recent boom in production of natural gas from Marcellus shale in the state and region. Natural gas is a "game changer" that will lead to a "gold rush that will build a completely new economy," Heywood contended. He noted that 10 hotels are rising in a rural county that had not seen construction in decades. Natural gas production could also spur job creation, he said; as energy costs decline, industries are bringing manufacturing jobs back to the United States because they are now cost-competitive. New companies can also use natural gas from the Marcellus shale to produce butane and propane, creating jobs in the process, agreed Burdette.

Environmental concerns linked to the use of hydraulic fracturing to produce natural gas were notably absent from the discussion. Although forum organizers had specified that environmental concerns were beyond the scope of the event, many attendees privately expressed great concern that speakers did not seem to recognize the potential dangers of hydraulic fracturing—particularly to local, state, and regional water systems. West Virginia's "water is an amazing resource, and we do a good job of protecting it," one speaker asserted—a view clearly disputed by many in attendance.

The state's environmental attributes relate directly to economic development. As noted, many speakers cited the potential for West Virginia's natural beauty to attract tourists, especially for outdoor recreation. In fact, out-of-staters often first learn about the state through tourism, Spellman pointed out. A tourist magnet can also be a magnet for businesses, observed Wender. Natural amenities can even induce out-of-state business owners to move their operations to the state. West Virginia's natural beauty also provides a foundation for a high quality of life, forum participants noted.

The state's proximity to major population centers is also an advantage, allowing for easy distribution of manufacturing products in a world where transportation costs are high. And that, in turn, makes the prices of goods more competitive, said Yura.


West Virginia Commerce Secretary Keith Burdette (center) responds to a question from an audience member. Also pictured are John Weete (left) and Kenny Perdue (right).

Stacy Jarrell

West Virginia's people rank as one of the state's greatest resources, forum participants agreed, citing their hardworking nature. West Virginians are "creative and resourceful and kind," and have a solid sense of place and community, Heywood maintained. "There are none better than the workers in West Virginia," concurred Kenny Perdue, president of the West Virginia AFL-CIO.

The state's strong universities and facilities are also key assets for economic development, according to the speakers. Research universities are the primary drivers of innovation, and state funding for research and development is critical, said panelist John Weete, executive director of Auburn University's Research and Technology Foundation. Panelist Jim Casto of the Robert C. Byrd Institute for Advanced Flexible Manufacturing (RCBI) noted that it leases some $6.5 million worth of equipment to enable entrepreneurs to make prototypes and test production runs.

Workforce development programs at community and technical colleges, and apprenticeship programs for skilled workers, enable state residents to qualify for well-paying jobs, speakers agreed. The RCBI's network of manufacturing centers has provided thousands of hours of training and assistance to manufacturers across West Virginia and the region.

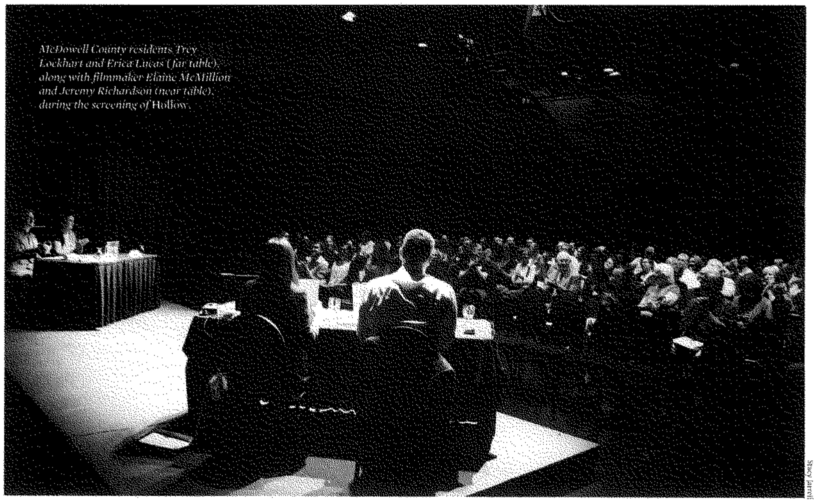
Panelist David Satterfield, interim director of the West Virginia Manufacturing Extension Partnership—which also trains workers and provides technical assistance to businesses—underscored the importance of encouraging the next generation to seek and train for manufacturing jobs. "We're going to take 160 fifth-graders into manufacturing facilities so they can have that inspirational moment."

West Virginia's Challenges

While the Bright Future forum focused on solutions, participants and speakers alike found it difficult to discuss visions for the future without confronting problems of the past and present. Those problems include prescription drug abuse, poor educational outcomes, declining population, lack of access to health care, persistent poverty, and environmental degradation. While companies praise the state's workforce, they also express concern about "how deep the bench is," and about ensuring not just a skilled workforce but one that is drug-free, Burdette noted. "We can't make someone drug-free or force them to get an education, but we can offer opportunities," he said.

The forum featured a screening of *Hollow*, a documentary featuring the stories of the people of McDowell County, which exemplifies the problems facing West Virginia and other rural areas in the region. Elaine McMillion, the film's director and producer, and a West Virginia native, spoke about her vision for the project, which includes short videos as well as interactive data—all available online. A panel discussion featuring two young McDowell residents accompanied the screening.

Many county residents—including several profiled in the film—made the two-hour drive to attend the screening. One McDowell church leader observed that residents had simply decided to stop waiting for help from the state and "do it ourselves." Despite the enormous odds, they expressed optimism about a better future for the home they love, and continue to work toward it.



McDowell County residents Trey Lockhart and Erica Lucas (far table), along with filmmaker Elaine McMillion and Jeremy Richardson (near table), during the screening of Hollow.

Stacy Jarrell

© NREL

Florida Power and Light's Mountaineer Wind Energy Center produces a maximum of 66 megawatts of electricity. Each turbine stands 228 feet above Backbone Mountain and has blades of 115 feet that weigh just over eight tons.

> ***The power is already here.***
> *—Kristen Barker, president, Cincinnati Union Co-op Initiative*

What's Next

The Bright Future forum broke new ground in West Virginia. In so doing, it revealed core themes that resonate among a broad cross section of West Virginians. These include the importance of projecting a positive vision of the state's future, fostering economic development, creating new jobs, and protecting the place people call home so future generations can live, work, and thrive here. The fact that both speakers and attendees represented a wide range of fields and views prompted Spellman to emphasize inclusiveness in his closing remarks: "Cognitive diversity leads to better decisions. When we have people engaged from different perspectives, we are going to end up with a more sound decision-making process, resulting in better decisions for our future."

The three organizations that sponsored the forum have pledged to continue to advance the conversation about West Virginia's economic future, possibly through joint reports or more public events. UCS, in particular, is talking with both sponsors and stakeholders about how it can help promote creative thinking about economic diversification in West Virginia and the broader Appalachian region.

Like West Virginia, other states in the region depend heavily on coal—through the mining industry and the electricity sector—and face many of the same challenges. UCS hopes not only that the Bright Future forum can catalyze changes in West Virginia, but also that ideas from the forum can inform similar events throughout the region. West Virginians can serve as leaders in advancing these ideas.

Despite the forum's success, online evaluations and conversations with participants revealed significant disappointment that it avoided a frank discussion of the environmental impact of extractive industries and their contribution to climate change. Many participants expected these topics to receive greater attention, given UCS's long-standing efforts to raise awareness of climate change and the potential for renewable energy and energy efficiency to mitigate it. UCS hopes the event has helped make room for state leaders to begin to consider these concerns, rather than avoiding the implications of climate science for the state's coal industry.

The Bright Future forum is only one first step in building West Virginia's future. Creating trust and forging consensus among citizens and decision makers about how best to move forward will take time. However, the positive spirit embodied by speakers and participants was palpable. Barker summed it up well: "West Virginia has everything it needs. There is remarkable creativity here already, and you just need to tap into it. The power is already here."

Jeremy Richardson *is a senior energy analyst in the UCS Climate and Energy Program. He comes from a coal-mining family in West Virginia and is conducting research into economic diversification in the state.*

CONFERENCE ORGANIZERS

The ***Union of Concerned Scientists*** *puts rigorous, independent science to work to solve our planet's most pressing problems. Joining with citizens across the country, we combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe, and sustainable future.*

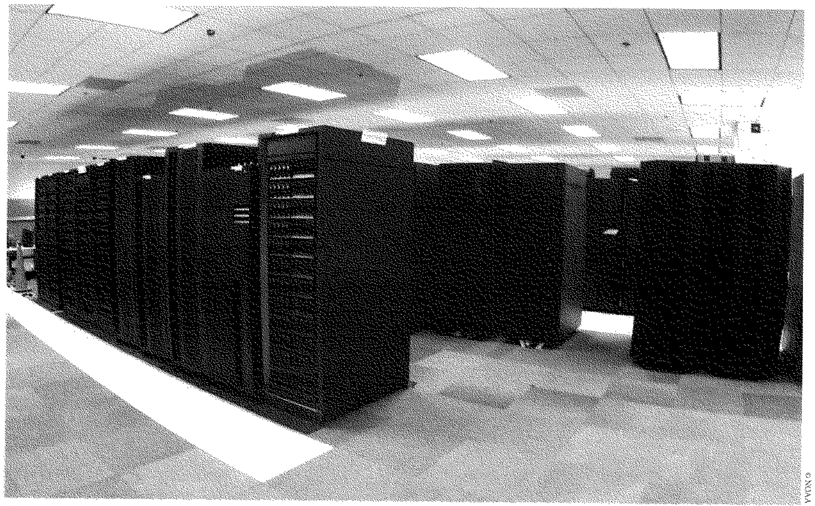
The ***West Virginia Center on Budget and Policy*** *is a policy research organization that is nonpartisan, nonprofit, and statewide. The Center's research and analysis is designed to support informed public dialog and policy in West Virginia. The Center consults and collaborates with other organizations to ensure that its analyses are relevant and timely and strives to be a knowledgeable and respected source of credible information on public budget and fiscal issues for policy makers, advocates, media, and the public.*

The ***West Virginia Community Development Hub*** *is a statewide nonprofit organization that works to engage communities and organizations in a system of community development that is locally determined and directed, continuous, intentional, and aligned across all three sectors of society (public, private, and civil).*

ACKNOWLEDGMENTS

The "Bright Economic Future for the Mountain State" forum was made possible by the support and partnership of several organizations: the West Virginia Center on Budget and Policy and its staff, Ted Boettner and Alyson Clements, and the West Virginia Community Development Hub and its executive director, Kent Spellman. The event received early and valuable guidance from James Van Nostrand, director of the Center for Energy and Sustainable Development at the West Virginia University College of Law. Principal funding for the event came from the Union of Concerned Scientists' Kendall Fellowship program.

Several UCS staff made important contributions to this event and report, including Angela Ledford Anderson, Kate Cell, Michelle Davis, and Jeff Deyette. I thank my Kendall Fellowship committee: Rachel Cleetus, Steve Clemmer, Jeff Deyette, and Peter Frumhoff.



© NOAA

The National Oceanic and Atmospheric Administration's Environmental Security Computing Center in Fairmont, WV, will develop and improve the accuracy of global and regional climate and weather model predictions.

[APPENDIX A]

Forum Agenda

Tuesday, September 3, 2013

6:00 PM–8:00 PM
Evening Reception *(Grand Foyer)*
Keynote Address
Jeff Kessler, President, West Virginia Senate
Natalie Tennant, West Virginia Secretary of State

Wednesday, September 4, 2013

7:30 AM–8:30 AM
Registration and Breakfast *(Grand Foyer)*

8:30 AM–8:35 AM
Welcome and Introductory Remarks *(Walker Theater)*
Jeremy Richardson, Union of Concerned Scientists

8:35 AM–9:00 AM
Keynote Address *(30 min)*
Tom Heywood, Managing Partner, Bowles Rice

9:00 AM–10:30 AM
Visions: West Virginia in 30 Years *(90 min)*
Moderator: Beth Vorhees, West Virginia Public Broadcasting
The Honorable Alan B. Mollohan
Scott Rotruck, President, Scott Rotruck & Associates
Anne Barth, Executive Director, TechConnectWV
Matt Ballard, President/CEO, Charleston Area Alliance

10:30 AM–11:00 AM
Break

11:00 AM–11:20 AM
Surprising Support for Economic Diversification *(20 min)*
Daniel Gotoff, Partner, Lake Research Partners

11:20 AM–11:40 AM
The Proposed West Virginia Future Fund *(20 min)*
Ted Boettner, Executive Director, West Virginia Center on Budget and Policy

11:40 AM–12:00 PM
A Roadmap for Sustainable Economic Development in West Virginia *(20 min)*
Jeremy Richardson, Union of Concerned Scientists

12:00 PM–1:15 PM
Lunch *(Grand Foyer)*
Special Guest: The Honorable Jay Rockefeller, U.S. Senator

1:15 PM–2:45 PM
Pathways: Economic Development and Workforce Training *(Walker Theater)*
Moderator: Beth Vorhees, West Virginia Public Broadcasting
John Weete, Executive Director, Auburn Research and Technology Foundation
Keith Burdette, West Virginia Secretary of Commerce
Kenny Perdue, President, WV AFL-CIO
David Satterfield, Interim Director, WV Manufacturing Extension Partnership, West Virginia University
James Casto, Associate Director of Public Information, Robert C. Byrd Institute
James Skidmore, Chancellor, WV Council for Community and Technical College Education

2:45 PM–3:15 PM
Break

3:15 PM–4:45 PM
Action: The Sky is the Limit
Moderator: Kent Spellman, Executive Director, WV Community Development Hub
Chris Yura, Founder, SustainU Clothing
Jeff Allen, Executive Director, West Virginia Council of Churches
Rebecca Randolph, President, Vision Shared
Matt Wender, President, Fayette County Commission
Kristen Barker, President, Cincinnati Union Co-op Initiative

4:45 PM–5:00 PM
Concluding Remarks: What Did We Learn?
Kent Spellman, Executive Director, WV Community Development Hub

5:30 PM–7:00 PM
Dinner *(Grand Foyer)*

7:30 PM–9:00 PM
Evening Public Screening: *Hollow* *(Walker Theater)*
Elaine McMillion, Director and Producer
Trey Lockhart, Student Representative, Reconnecting McDowell
Patrick Corcoran, Assistant to the Director, McDowell Public Library
Erica Lucas, McDowell County resident

[APPENDIX B]

Participants

Peni Adams, executive director, McDowell County Economic Development Authority
Peni works to create and retain jobs in McDowell County.

Angela Ledford Anderson, *director, Climate and Energy Program, Union of Concerned Scientists*
Angela is the director of the Climate and Energy Program at the Union of Concerned Scientists (UCS). She is leading UCS's efforts to persuade government officials to enact policies that encourage clean energy and result in global warming emissions reductions.

Rob Anderson, *executive vice chancellor for administration, West Virginia Higher Education Policy Commission*
Rob directs the internal administration for the two- and four-year public college systems in West Virginia.

Teddy Armbrecht, *owner, The Wine Shop @ Cap Mrkt.*
Teddy is interested in organic commodities. He is also an avid mountain and road biker.

Linda Arnold, *chairman and CEO, The Arnold Agency*
Linda is the chairman and CEO of The Arnold Agency, a marketing communications firm with offices in West Virginia, Montana, and Washington, DC. She also writes a regular column for the Sunday *Gazette-Mail* entitled, "Live Life Fully."

Amy Atkins, *director, Divison of Local Health, WV Bureau for Public Health*
Amy manages a unit of professionals in the WVBPH who work with local health departments.

Dianne Bady, *project coordinator, Ohio Valley Environmental Coalition*
Dianne's organization is working toward a community wind farm and solar panels at a coalfield health clinic.

Christy Bailey, *executive director, National Coal Heritage Area Authority*
We work to help diversify the economy in southern West Virginia by developing heritage tourism sites related to coal history and culture.

Kevin Baker, *counsel, West Virginia Senate Judiciary Committee*

Sandra Steiner Ball, *bishop of the WV Conference United Methodist Church*
Sandra leads the UMC as their bishop in the West Virginia and Garrett County, MD, area.

Neela Banerjee, *energy and environment reporter,* Los Angeles Times

Joe Barker, *director, Office of Community Health Systems and Health Promotion, WV Bureau for Public Health*
Joe manages an office of 65 staff working on various programs designed to improve the health of West Virginia citizens.

Kristen Barker, *president, Cincinnati Union Co-op Initiative*
Kristen helps build Mondragon union co-ops, with six initiatives under way in Cincinnati. Kristen helps support efforts across the country as well.

Rob Bastress, *attorney, DiTrapano, Barrett, DiPiero, McGinley, and Simmons*
Rob is a plaintiff's lawyer in Charleston.

Andrew Beckner, *communications, Office of Senator Jay Rockefeller*
Andrew coordinates Senator Rockefeller's relationship with the news media in West Virginia.

Jim Berner, *treasurer, United Methodist Church*
Jim is the treasurer for the United Methodist Church.

Belinda Biafore, *economic development and grant coordinator, Marion County Economic and Community Development*
Belinda works with the Marion County Economic and Community Development Office.

Gerald Biser, *assistant director, industrial extension, West Virginia University*
Jerry works within the Industrial Extension service and the West Virginia MEP program, providing manufacturing consulting and business management services to small to mid-size West Virginia companies.

Susan Blackwell

Ruth Blevins, *executive director, West Virginia Nurses Association*
Ruth is the executive director of the West Virginia Nurses Association, the membership organization for nurses in West Virginia.

Patrick Bond, *general partner, Mountaineer Capital LP*
Patrick is a venture capitalist.

Laura Bozzi, *program manager, Appalachian Mountain Advocates*
Laura works to protect the environment and surrounding communities from mountaintop removal. She also works to support sustainable economic transition efforts. She has recently initiated a local farms program to support sustainable agriculture in the Greenbrier Valley.

Kelly Bragg, *energy development specialist, WV Division of Energy*
Kelly provides information and technical assistance to West Virginia residents relating to energy efficiency, renewable energy, and alternative fuels.

Barbara Braun, *senior vice president and founder, Composite Transport Technologies*
Barbara is senior vice president of administration and marketing.

Bob Brown, *project manager, Reconnecting McDowell/AFT*
Bob manages a multi-faceted project in McDowell County that seeks to reform the education system by addressing all of the issues that impact students.

John Catselis, *investor, self-employed*
John manages commercial and residential real estate in Charleston, and is on the board of The Arnold Agency, a marketing communications firm.

Kate Cell, *outreach coordinator, Union of Concerned Scientists*
Kate is project manager of the coastal impacts group at the Union of Concerned Scientists.

Becky Ceperley, *president and CEO, The Greater Kanawha Valley Foundation*
Becky runs a community foundation seeking to provide local wealth in six counties in West Virginia.

Lori Chaffins, *membership coordinator, West Virginia Nurses Association*
Lori works for the West Virginia Nurses Association, an affiliate of the American Nurses Association.

Daniel Chiotos, *organizer for energy efficiency, Sierra Club*
Daniel brings West Virginia residents and organizations together to push for the job creation and lower utility bills that would come from expanded energy efficiency programs.

Holly Clark, *director, Telework West Virginia*
Holly seeks to place more West Virginians in work-from-home jobs.

Alyson Clements, *outreach coordinator, WV Center on Budget and Policy*
Alyson works to bridge West Virginia Center on Budget and Policy research reports with low- and moderate-income families, legislators, press, and public.

Dan Conant, *principal, Solar Holler, LLC*
Dan works with small towns and communities across West Virginia to organize and invest in clean energy projects that will sustain our towns and the environment.

Ellis Conley, *MonValley District superintendent, West Virginia Annual Conference*
Ellis is one of nine district superintendents in the West Virginia Annual Conference United Methodist, overseeing 70 pastors and 163 congregations in north-central West Virginia.

Patrick Corcoran, *assistant to the director, McDowell Public Library*
Patrick assists the general public in gaining and utilizing information. Most recently, his library has been able to assist Elaine McMillion and her *Hollow* crew in the empowerment of community members.

Patrick Crane, *director of policy and strategy, WV Higher Education Policy Commission*
Patrick works for the state agency overseeing all public colleges and universities in the state. His job includes research, advocacy, policy making, and grant writing to benefit West Virginia students.

Pam Curry, *executive director, Center for Economic Options*

Ginger Danz, *distance learning coordinator, Bridgemont Community and Technical College*
Ginger works to bring telework jobs to West Virginia in order to diversify the economy and strengthen communities.

Michelle Davis, *energy-water program assistant, Union of Concerned Scientists*
Michelle Davis is the energy-water research assistant for the UCS Climate and Energy Program, where she does research and outreach for the Energy and Water in a Warming World Initiative.

Bill Denham, *Spanish teacher, Riverside High School*
Bill is a high school Spanish teacher at Riverside High School and believes in providing students with authentic learning experiences and language immersion.

John Deskins, *director, Bureau of Business & Economic Research, West Virginia University*
John's bureau's mission is to provide the West Virginia community of business and public-sector decision makers with economic analysis and forecasts, applied business and economic research, and information on economic, demographic, and business trends in the state and its regional economies.

Jeff Deyette, *assistant director, energy research, Union of Concerned Scientists*
Jeff is the assistant director of energy research and a senior energy analyst in the Climate and Energy Program at the Union of Concerned Scientists. He conducts analysis on the economic and environmental costs and benefits of renewable energy and energy efficiency policies.

Robert Diznoff
Robert works on federal policy related to energy, environment, energy efficiency, and advanced manufacturing.

Rose Edington, *minister and Echo Justice advocate, change agent, UUC*
Rose is a native West Virginian, OVEC board member, Energy Efficiency Committee, Green Sanctuary Program.

Chris Espinosa, *legislative representative, Earthjustice*
Chris is the legislative representative engaging government on clean water issues on behalf of Earthjustice.

Sandra Fallon, *education and training, National Environmental Services Center*
Sandra develops training, education, and informational programs/materials on water issues (protection, sustainability, integrated management).

Frank Fineis, *intern, Sustainable Williamson*
Frank is an intern with Sustainable Williamson, a campaign to redefine the economic landscape of coal country.

V. Diane Freeman, *CEO, Ferguson Manning Associates*
Diane owns a consulting firm working in the oil and natural gas industry. She works with corporations, community leaders, and government officials to identify business opportunities for minorities, women, veterans, and small businesses in West Virginia and the surrounding area.

Carol Fulks, *executive director, WV Hospitality & Travel Association*
Carol represents the private tourism industry in West Virginia through day-to-day operations consulting and governmental relations.

Tricia Fulks, *associate producer, Hollow Interactive*
Tricia is an associate producer for *Hollow: An Interactive Documentary*, an online documentary about McDowell County, WV, through the eyes of its residents.

Jake Glance, *communications and media, West Virginia Secretary of State's Office*
Jake handles all communications and media for the West Virginia Secretary of State's Office.

Stacy Gloss, *project manager, Energy Efficient West Virginia*
Stacy is a project manager for Energy Efficient West Virginia, which works to advance energy efficiency in the Mountain State.

Crystal Good, *development, West Virginia State University*
Crystal works in marketing and development at West Virginia State University.

Brenda Grant, *strategic planning, CAMC*
Brenda does strategic planning for the Charleston Area Medical Center Health System.

Ed Grant, *district superintendent, The United Methodist Church*
Ed works with pastors in his district.

Marley Green, *organizer, Sierra Club*
Marley works on water quality and economic transition issues in the southwest Virginia coalfields.

Victor Grigoraci, *accountant, Hayflich Grigoraci PLLC*
Vincent has over 40 years of public accounting experience and over four years as an internal revenue agent. He is also a Personal Financial Specialist (PFS) and a Certified Financial Planner (CFP).

Sarah Halstead, *community and economic development, WV State University*
Sarah does program development to support innovation economy growth.

Evan Hansen, *president, Downstream Strategies*
Evan performs science and policy research related to resource environmental and economic issues facing West Virginia. Downstream Strategies offers environmental consulting services that combine sound interdisciplinary skills with a core belief in the importance of protecting the environment and linking economic development with natural resource stewardship.

Zack Harold, *reporter,* Charleston Daily Mail

Bradley Harris, *executive assistant, West Virginia Secretary of State's Office*
Bradley is the executive assistant to the West Virginia secretary of state.

Elaine Harris, *international representative, Communication Workers of America*

Wess Harris, *educator, organizer, Appalachian Community Services, Inc.*
Wess's focus is to teach union history while exposing efforts to sanitize our heritage. He uses factual depictions of our past to motivate young folks to take action to allow us to have a future.

Gregory Hayes, *superintendent, Western District, United Methodist Church*
Gregory is the superintendent of the Western District of the United Methodist Church. The district is comprised of more than 100 United Methodist churches in Mason, Lincoln, Cabell, Wayne, and Mingo counties.

Paul Hill, *chancellor and CEO, WV Higher Education Policy Commission*
Paul is chancellor and CEO of the WV Higher Education Policy Commission.

Mel Hoover, *minister and Echo Justice advocate, change agent, UUC & Tuesday Morning Group & WV UU Advocacy Network*
Mel is a longtime change agent in justice work and environmental issues. Mel is also a coordinator of Sustainable Kanawha Valley Initiative, and a speaker and workshop leader on Echo Justice.

Aaron Huertas, *press secretary, Union of Concerned Scientists*
Aaron works with the media to promote the work of the Climate and Energy Program and Center for Science and Democracy. During his time at UCS, he has conducted more than a dozen communications workshops for scientists, co-written several UCS reports, and helped design the UCS climate education card game, *Cool It!*

Rachel Huff, *education and outreach director, WV FREE*
Rachel spearheads advocacy education and social media work around young people, health care, and reproductive justice at WV FREE. As a 25-year-old female she has a sincere interest in ensuring our state's future has youth voices and input.

Mark Imbrogno, *attorney, Jackson Kelly PLLC*
Mark specializes in public finance and economic development.

Lloyd Jackson, *businessman, natural gas industry*
Lloyd is a businessman in the natural gas industry. He is a member of the State Board of Education and a trustee of the Benedum Foundation.

Josh Jarrell, *general counsel, WV Department of Commerce*
Josh is the general counsel of the WV Department of Commerce, which houses the WV Division of Energy.

Courtney Jesser, *vice chair, Generation Greenbrier Valley*
Courtney is a substitute teacher with Greenbrier County Schools. She also serves as vice chair of Generation Greenbrier Valley.

Lou Ann Johnson, *policy director, West Virginia Secretary of State's Office*
Lou Ann is the policy director in the West Virginia Secretary of State's Office.

Rebecca Kimmons, *director, Create WV Conference on The Future, Create West Virginia*
Rebecca is an economic development strategist using innovation economy principles.

Carrie Kline, *owner of folklife preservation organization, oral historian and musician, Talking Across the Lines*
Carrie preserves knowledge of the local arts of daily living, music, and narrative arts, and records and shares oral testimonials interweaving viewpoints on a variety of community issues.

Michael Kline, *oral historian and musician*
Michael preserves knowledge of the local arts of daily living, music, and narrative arts by recording and sharing oral testimonials interweaving viewpoints on a variety of community issues.

Betty Knighton, *director, WV Center for Civic Life*
Betty is the executive director of the WV Center for Civic Life, a nonpartisan, nonprofit organization that promotes civic engagement throughout the state. A primary focus of her work is in helping communities develop ways to talk and work together on issues that affect the quality of life in West Virginia.

Jill Kriesky, *associate director, SWPA Environmental Health Project*
The SWPA Environmental Health Project responds to individuals' and communities' need for access to accurate, timely, and trusted public health information and health services associated with natural gas extraction.

Ken Krimmel, *dean of the cabinet, WV Conference, The United Methodist Church*
Ken works with the bishop of the West Virginia Conference of the United Methodist Church.

Catherine Kunkel, *consultant, Kunkel Energy Research*
Catherine primarily works with Energy Efficient West Virginia to strengthen utility-funded energy efficiency programs in West Virginia.

JF Lacaria, *director, The United Methodist Church WV Conference*
JF is the assistant to the bishop and director of program ministries for the WV Conference of the UMC.

Lin Lacaria, *pre-school director, Cross Lanes UMC*
Lin directs and teaches in the pre-school program at Cross Lanes UMC, Cross Lanes WV.

Katey Lauer, *coalition coordinator, The Alliance for Appalachia*
Katey's work has traditionally focused on impacts to health and water quality from strip-mining and other coal industry practices.

Colt Legg, *doctor, CAMC*
Colt is a medical resident at the Charleston Area Medical Center.

Bobby Lewis, *state director, USDA Rural Development*
Bobby serves as the state director for USDA Rural Development. This federal agency invested approximately $387 million in rural West Virginia in FY 2012.

Conni Gratop Lewis, *American Friends Service Committee*
Conni volunteers with the AFSC Economic Justice Project, focusing on minorities' and women's needs in economic development work.

Trey Lockhart, *student*
Trey is a graduate of McDowell County, and a student representative for AFT Reconnect McDowell.

John Maher, *vice president for research, Marshall University*
John is the vice president for research at Marshall University and the executive director of the Marshall University Research Corporation. He is also currently serving as interim director of the Marshall Institute for Interdisciplinary Research.

Kenisha Manning, *president, KJM Custom Designs*
Kenisha creates and designs custom jewelry.

Tara Martinez, *executive director, Women's Commission*
Tara's commission conducts advocacy, education, and research on women's issues in the state.

Lynette Maselli, *media specialist, WV Senate*
Lynette is the media specialist for Senate President/Lt. Governor Jeff Kessler.

Joseph Mathis, *commissioner, The City of Williamson*
Joseph also works with Sustainable Williamson to redefine the economic landscape of coal country.

Nate May
Nate is a musician and composer from Huntington, WV.

Tim McClung
Tim is interested in Future Fund and establishing a public bank in West Virginia.

Karen McElhinny, *lawyer, Shuman, McCuskey & Slicer*
Karen is a lawyer in Charleston.

Jim McGoldrick, *executive director, Pleasants County Development Authority*
Jim is executive director of Pleasants County Development Authority and is seeking to improve quality of life for this rural county by adding jobs, tax base, services to businesses and industry, and infrastructure.

Rory McIlmoil, *director of energy policy, Appalachian Voices*
Rory brings people together to protect the land, air, and water of central and southern Appalachia.

Morgan McKinney, *registered nurse*
Morgan is an RN, currently practicing in urgent care and community nursing settings. From Wyoming County, Morgan is passionate about West Virginia and dedicated to working toward sustainable development in all sectors of society for our state.

Elaine McMillion, *director and producer,* Hollow *documentary*
Elaine is the director and producer of *Hollow*, the interactive documentary film that will be shown as part of this forum.

Justin McMillion

Rita McMillion

Rebecca McPhail-Randolph, *president/CEO, Vision Shared*
Rebecca is the president of a statewide nonprofit economic development organization.

Joe Mearman, *president, Energy Efficient Technologies*

Brandy Messer, *director of economic development, Office of Senator Jay Rockefeller*
Brandy is on the staff of Senator Rockefeller.

Sandra Mikush, *deputy director, Mary Reynolds Babcock Foundation*
The Babcock Foundation supports efforts to move people and places out of poverty, and is particularly interested in community development and policy efforts that advance a just and sustainable economic transition in Appalachia.

Dave Mistich, *reporter, West Virginia Public Broadcasting*
Dave is a reporter in Charleston who focuses on stories happening in the capital city and surrounding areas.

Ann Murray, *radio reporter/producer*
Anne produces environmental news for various public radio venues including NPR News, Living On Earth, and Voice of America.

Jane Nalle
Jane is attending to hear one of the speakers, Jeremy Richardson.

Cullen Naumoff, *Vision 2030 project director, Charleston Area Alliance*
Cullen works on long-term strategic economic development founded in the triple bottom line using the economic gardening approach.

Brandon Nida, *organizer, Blair Mountain Heritage Alliance*
Brandon works to build a sustainable economy through self-initiative and pragmatic step-up strategies.

Brian ODonnell, *director, social ministries, Diocese of Wheeling Charleston*
Brian works for social justice concerns for the Catholic Diocese.

Martha Ogniben, *district superintendent, United Methodist Church*
Martha is a clergy person supervising a district of clergy in the northern panhandle of West Virginia for the United Methodist Church.

Stephanie Ojeda, *assistant general counsel, Patriot Coal Services*
Stephanie serves as in-house counsel for Patriot Coal Services in Charleston.

Sean O'Leary, *columnist and blogger,* The State of My State
Sean writes a bi-weekly column on West Virginia economics and policy for the *Martinsburg Journal* and other newspapers.

Asley Orr, *director of outreach and events, Office of Senator Jay Rockefeller*
Asley is the director of outreach and events for the Office of Senator Jay Rockefeller.

Kate Ortenzi, *intern, Sierra Club Beyond Coal Campaign*
Kate is a master's student at the University of Maryland in conservation biology and public policy. She is currently interning at the Sierra Club, focusing on the economic transition of Appalachia with the elimination of MTR.

Misty Peal, *GR specialist, WVEA*
Misty is a lobbyist for an educational employment professional organization.

Guy Peduto, *director, INNOVA Commercialization Group*
The INNOVA Commercialization Group, an initiative of the West Virginia High Technology Consortium Foundation, is a business-support services and seed and early-stage investment capital program dedicated to creating successful entrepreneurs and new ventures. INNOVA specializes in bringing vital knowledge and resources to seed and early-stage companies in support of product commercialization efforts.

Sam Petsonk, *mining health and safety advocate*
Sam is an advocate for coal miners' health and safety, and is involved in community economic development programming in the greater Beckley area.

Carson Pfeifer, *intern, Sierra Club*
Carson works for the Beyond Coal campaign for the Sierra Club.

Mimi Pickering, *director, Community Media Initiative, Appalshop*

Margaret Chapman Pomponio, *executive director, WV FREE*
Margaret works on women, youth, and families advocacy and on reproductive health education.

Jessica Pressman, *benefits administrator, Veterans Administration*
Jessica is a veterans' benefits administrator and community volunteer with Create Huntington.

Bill Price, *organizing representative, Sierra Club*
Bill works on energy efficiency as part of a campaign to move to cleaner energy generation.

James Probst, *owner, Probst Furniture Makers*
James owns and operates a furniture manufacturing business in Lincoln County that builds high-end furniture to James's design. Work is shipped all over the United States.

Calentha Quesenberry, *executive director, Historic Fayetteville Convention & Visitors Bureau*

Regan Quinn, *musician, legal researcher, WV Symphony Orchestra*
Regan researches medical issues and recruits experts for law firms. She is also a musician with the West Virginia Symphony Orchestra.

JW Randolph, *energy savings associate, Appalachian Voices*
JW has worked to protect citizens from mountaintop removal at the local, state, and federal level, and now works on implementing energy efficiency in the rural southeast.

Phoebe Randolph, *architect, Edward Tucker Architects Inc.*
Phoebe is an architect and a community volunteer with Create Huntington.

Steven Richards, *university professor, West Virginia State University*
Steven is the program director for Parks, Recreation & Tourism Studies at WVSU. He teaches an undergraduate course in sustainable development and introduces sustainability issues into core curriculum.

Rosella Richardson

Warren Richardson

Charlie Rittenhouse, *president, UWUA Local 69 AFL-CIO*
Charlie represents gas workers of Dominion in six states.

Betty Rivard, *photographer, West Virginia Homeplace*
Betty is a fine art landscape photographer, an editor of a book of historic photographs, and a producer of art fairs.

Rebecca Roth
Rebecca consults with area nonprofits on grant writing and strategy.

Tom Saladyga, *assistant professor of geography, Concord University*
Tom teaches courses within the broad fields of physical geography, sustainability studies, and geographic information systems (GIS). His research focuses on forest ecosystem stability and resilience in the context of changing climate, land use, and/or management strategies.

Danny Scalise, *chief executive officer, EnAct*

Jim Sconyers, *chair, WV Sierra Club*
Jim works for an end to coal-fired power and for renewable/sustainable energy, clean air, and clean water.

Janet Scott
Janet lives in Wyoming County.

Amy Shanholtzer, *director of evangelism and congregational development, WV United Methodist Church*
Amy works with United Methodist churches across West Virginia on issues of vitality and community engagement.

Lisa Sharp, *director of Rural Business-Cooperative Service, USDA Rural Development*
Lisa manages the business programs division within USDA Rural Development in West Virginia. She also serves as the rural development coordinator, a liaison between the agency's programs and communities, organizations, and individuals across the state.

Kerrin Sheldon
Kerrin creates marketing videos for brands and tourism agencies, helping to create excitement around messages, events, and promotions.

Sally Shepherd, *farmer*
Sally is a small farm owner/operator and a clean energy advocate.

Walton Shepherd
Walton was a law student at WVU College of Law's Center for Energy and Sustainable Development, and is now looking to continue working in sustainable development as a way to address West Virginia's long-term structural challenges.

Stephen Smith, *director, WV Healthy Kids and Families Coalition*
Stephen works to fight poverty in West Virginia.

Beth Spence, *American Friends Service Committee*
Beth works to advance economic and social justice in West Virginia.

Robert Stonestreet, *attorney, Dinsmore*

Margaret Stout, *assistant professor, West Virginia University*
Margaret is a public administration scholar with a focus on local governance and community development.

Carolyn Stuart, *executive director of Herbert Henderson Office of Minority Affairs, Office of the Governor*
Dr. Stuart is responsible for conducting forums to allow minority citizens the opportunity to voice their issues and collaboratively work together to develop strategies to effectively deal with the issues.

John Suggs, *managing director, SWPA Environmental Health Project*
The SWPA Environmental Health Project responds to individuals' and communities' need for access to accurate, timely, and trusted public health information and health services associated with natural gas extraction.

Aaron Sutch, *energy program manager, The Mountain Institute*
Aaron implements solar and energy efficiency projects that empower communities to utilize renewable energy and efficiency to create economic opportunity and mitigate rising energy costs.

Dan Taylor, *project coordinator, Ohio Valley Environmental Coalition*
Dan is a project coordinator for the Ohio Valley Environmental Coalition, working on projects involving energy efficiency, renewable energy, economic transition, and clean elections.

Jan Taylor, *director, Division of Science and Research, Higher Education Policy Commission*
Jan works with faculty to help them be more competitive for federal grants, and supports economic development from intellectual property created at our colleges and universities.

Rachel Terman*, student, Penn State University*
Rachel is a PhD student in rural sociology and women's studies at Penn State. Her dissertation work is on the social factors that affect young college-educated people in West Virginia.

Tom Torres
Tom works on community economic development in Tennessee and Alabama.

Kristin Tracz*, program officer, Blue Moon Fund*
Kristin manages Blue Moon's investments in the United States, which includes West Virginia and Kentucky.

Sarah Tucker*, vice chancellor for community and technical college education, WV Council for Community and Technical College Education*
Sarah is responsible for working with education policy information professionals to conduct research in support of state-level master planning, legislative accountability, student access and success, retention and persistence, and enhanced policy analysis for decision making.

Allan Tweddle*, CEO and founder, Composite Transport Technologies*
Allan's company is an SME that will manufacture unique aircraft parts. These parts will reduce the carbon footprint of every Boeing and Airbus aircraft that uses them. Allan's company is also committed to achieving a zero-carbon footprint in all operations.

Stephanie Tyree*, director of community engagement and policy, WV Community Development Hub*
Stephanie works with communities in southern West Virginia and throughout the state to create pathways for stakeholders to engage with their decision makers at the local and state level, and relating to regulatory and legislative policy.

Ken Ward*, staff writer,*
Charleston Gazette
Ken is a staff writer for the *Charleston Gazette.* He is also creator and author of the *Coal Tattoo* blog.

Matthew Wasson*, director of programs, Appalachian Voices*
Matt is director of programs at Appalachian Voices, an organization that empowers people to defend our region's rich natural and cultural heritage by providing them with tools and strategies for successful grassroots campaigns.

Beth Wheatley, *director of external affairs, The Nature Conservancy*
Beth works in partnership with government, industry, landowners, and others to conserve and restore important lands and waters in West Virginia, with a specific focus on energy development.

Ken White*, vice president of resident services, NHP Foundation*

Elizabeth Wiles*, executive director, Friends of Deckers Creek*
Elizabeth works to improve the water quality in north-central West Virginia and prevent future pollution. She believes a healthy environment is the foundation for a healthy and diversified economy.

Robin Wilson*, organizer, WV 350 Reversing Climate Change*
Robin has worked on peace, justice, and community development most of her adult life. Now at 71 she's working on reversing climate change and resource depletion.

John Wirts*, Watershed Assessment, WVDEP–DWWM*
John is with WVDEP's DWWM, managing the Watershed Assessment Branch, which monitors and assesses the chemical, physical, and biological integrity of the state's waters.

Gary Zuckett*, executive director, WV Citizen Action Group*
Gary works on issues of economic, social, and environmental justice in West Virginia.

[APPENDIX C]

Speaker Biographies

REV. JEFFREY ALLEN
Jeffrey S. Allen is a United Methodist pastor currently appointed to the West Virginia Council of Churches as the executive director. He holds a bachelor of arts degree in biology and a bachelor of arts degree in religious studies from West Virginia University and a master of divinity degree from Emory University. He previously served as project director for the West Virginia Healthy Kids and Families Coalition, as the community and families development director at Community Development Outreach Ministries (CDOM) for 13 years, and has also served as pastor at the Keystone and Northfork United Methodist Churches in McDowell County, WV, and the College Hill United Methodist Church in Waco, KY.

MATT BALLARD
Matthew Ballard is the president/CEO of the Charleston Area Alliance and its affiliate, the Charleston Regional Chamber of Commerce. Ballard and the Alliance have played an integral role in the recruitment of new jobs, the development of our urban areas as well as leading several regional projects that have led to new economic opportunities. In public policy, Ballard has been a voice for innovative job creation policies that would position West Virginia to excel in coming decades, including economic development initiatives and utilizing incentives that address the crisis of student loan debt as a population and workforce attraction tool for the state. Ballard is a West Virginia native, originally from Shinnston, WV. He holds an undergraduate degree from Alderson Broaddus College in nursing and a master's degree in public administration from West Virginia University. Ballard lives in Elkview with his wife Staci and daughters Sylvia and Stella.

KRISTEN BARKER
Kristen Barker is the president of the Cincinnati Union Co-op Initiative (CUCI), which is based on the Mondragon-USW union co-op model. CUCI has launched one co-op and has five projects in various stages of feasibility/business planning. As a community organizer for the past 12 years, she fosters faith, labor, and community partnerships. She is the mother of a resilient daughter with special needs. Apart from two years in El Salvador, she is a lifelong resident of Cincinnati.

ANNE BARTH
Anne Barth is the executive director of TechConnect West Virginia, where she directs a variety of programs designed to diversify the economy by turning innovation into enterprise. In 2011 she was appointed by Governor Earl Ray Tomblin to the Southern Technology Council of the Southern Growth Policies Board. She serves on the NASA West Virginia Space Grant Consortium, the board of directors of the WV Biosciences Association, the board of Teaming to Win, the Charleston Area Alliance Vision 2030 innovation/R&D committee, the advisory board of the West Virginia Small Business Development Center, and was co-chair of the Environmental Issues Team for Power of 32, a 32-county, four-state regional visioning project. She was awarded the U.S. Small Business Administration District Director's Award in 2012. Ms. Barth holds a bachelor's degree in journalism and a master's degree in corporate and organizational communications from West Virginia University.

TED BOETTNER
As the co-founding executive director of the West Virginia Center on Budget and Policy, Ted brings a wealth of experience and understanding of state fiscal issues. In addition to running the Center, Ted is the author of numerous reports on state tax and budget issues, economic development, and family economic security, including the annual *State of Working West Virginia*. Ted frequently presents analyses of policy proposals to the West Virginia legislature and testifies before committees. He also regularly addresses statewide civic groups on state tax, budget, and economic policies and is frequently quoted in news stories on those topics. In 2013, Ted was appointed to a three-year term as a primary member of the U.S. Extractive Industries Transparency Initiative (USEITI), an advisory committee within the Department of the Interior. In 2011, the *State Journal* named Ted "one of the most influential businesses leaders" in West Virginia. Ted also serves on the board of directors of Cabin Creek Health Systems and Mountain State Justice and he is an adjunct instructor at West Virginia University Institute of Technology. Ted holds a BS in journalism from West Virginia University and an MA in political science from the University of New Hampshire.

KEITH BURDETTE
In December 2010, Keith Burdette was appointed by Governor Earl Ray Tomblin as cabinet secretary for the West Virginia Department of Commerce and executive director of the West Virginia Development Office. Keith Burdette began his public service when he was elected to the first of two terms in the West Virginia House of Delegates. In 1982 he was elected to the West Virginia state senate. In 1989 Keith was elected the forty-second president of the state senate at the age of 34—the youngest senate president in the state's history. Keith is actively involved in the Parkersburg community where he resides. He is married to the former Pat Haught Huffman and has two sons and two stepsons.

JAMES E. CASTO
Jim retired in 2004 from the *Herald-Dispatch*, where he was a reporter and editor for more than 40 years. He is now senior public information specialist at the Robert C. Byrd Institute for Advanced Flexible Manufacturing. Active in community affairs, he's a board member with the United Way of the River Cities, Goodwill Industries, the Huntington Area Food Bank, the Tri-State Area Boy Scout Council, the Friends of the Cabell County Public Library, the Marshall University Library Associates, and the West Virginia Faculty Merit Foundation. A native of Huntington, he attended Bethany College at Bethany, WV, and is a graduate of Marshall University, where he earned a bachelor's degree in journalism and a master's degree in English.

PATRICK CORCORAN
Patrick is assistant to the director of the McDowell Public Library. He assists the general public in gaining and utilizing information. Most recently, his library has been able to assist Elaine McMillion and her *Hollow* crew in the empowerment of community members.

DANIEL GOTOFF

Daniel Gotoff heads Lake Research Partners' New York office. Since joining the firm in 1996, Daniel has worked for candidates at all levels of the electoral process as well as on a wide range of issues, including the economy, national security, and government accountability. Daniel's tenure at LRP has included extensive research for clients, including presidential, senatorial, congressional, gubernatorial, and mayoral candidates, as well as the DNC, DCCC, and the NAACP National Voter Fund. He has also led the firm's overseas consulting on campaigns in Mexico and the Caribbean. Daniel's analyses of the American political landscape are regularly published and he is a contributor on *The Leon Charney Report* and other political and public affairs news shows. Gotoff holds a BA in history and Italian from the University of Michigan in Ann Arbor.

TOM HEYWOOD

Tom Heywood is the managing partner of Bowles Rice, a regional business law firm with seven offices in West Virginia, Kentucky, and Virginia. His practice areas are corporate, commercial, and finance law, government relations, and health care law. Upon graduation from law school, Tom clerked for the Honorable John A. Field, Jr., senior judge for the U.S. Court of Appeals for the Fourth Circuit. He joined Bowles Rice in 1983. From 1989 to 1990, Tom served as counsel to West Virginia Governor Gaston Caperton, and from 1990 to 1993 he served as Caperton's chief of staff. Tom returned to Bowles Rice in 1993. Tom remains active as a leader in many civic activities, and has led the following initiatives in recent years: chairman, Affordable Insurance Workgroup; co-chairman, Finance & Benefits Committee, Health Advisory Council; chairman, Results-Based Government Task Force, Vision Shared; chairman, TANF Advisory Council; chairman, Community and Technical College Implementation Board; co-chairman, Celebration 2000; co-chairman, Yes on 1 Committee (Stock Investment Amendment to West Virginia Constitution); chairman, Transition Committee on Medicaid; chairman, Medicaid Crisis Panel. Tom has also served as chairman or co-chairman of several Kanawha County school bond and levy advocacy groups in recent years. Tom earned his bachelor of arts degree from Stanford University in 1978 and his law degree in 1982 from Harvard Law School.

JEFF KESSLER

Senator Jeffrey V. Kessler was appointed to the West Virginia State Senate in November 1997 to fill a vacancy created by the death of Senator Larry Wiedebusch. He was then elected to the senate in 1998 where he served during the 75th Legislature as vice chairman of the Committee on Banking and Insurance and the Select Committee on Economic Development. Senator Kessler was re-elected in 2000, 2004, and 2008. During the 76th, 77th, 78th, and 79th Legislatures Senator Kessler served as chairman of the Committee on the Judiciary. Senator Kessler was elected senate president on November 14, 2011, following a one-year term as West Virginia's first and only acting senate president. Kessler received a BA from West Liberty State College and his JD from West Virginia University College of Law. Senator Kessler is married to Gretchen Kessler and has four children: Jacob, Lauren, Jackson, and Hastings.

TREY LOCKHART

Trey Lockhart is a graduate of McDowell County, and a student representative for AFT Reconnect McDowell.

ERICA LUCAS

Erica Lucas lives in Welch, WV. At times, she has lived outside the state before coming back to McDowell County and is now determined to make a positive change in her community. She is now a student at Bluefield State College where she can learn to better serve her community. She has high hopes for McDowell County's future.

ELAINE McMILLION

Elaine McMillion is an award-winning documentary storyteller based in Boston, MA. Her work explores how digital platforms and participatory media can empower local communities. Her current project, *Hollow*, strives to communicate the issues of rural America through the eyes, voices, and ideas of southern West Virginia. *Hollow* is funded by Kickstarter, Tribeca Film Institute's New Media Grant, and the West Virginia Humanities Council. It is supported by Documentary Educational Resources and the West Virginia Filmmakers Guild. Her op-doc "West Virginia, Still Home" was featured on the *New York Times* website on June 20, 2013. In the summer of 2013, *Filmmaker Magazine* named McMillion one of the "New Faces of Independent Film."

ALAN B. MOLLOHAN

Alan B. Mollohan is of counsel to Nelson Mullins Riley & Scarborough LLP in West Virginia. A former member of the United States House of Representatives, Mr. Mollohan served 14 terms, having been first elected in 1982 to represent West Virginia's 1st Congressional District. In the House, Mr. Mollohan held a number of committee assignments including serving as chairman of the Commerce, Justice, Science Appropriations Subcommittee. Prior to his election to Congress, Mr. Mollohan practiced law in West Virginia and Washington, DC. His practice included civil litigation, administrative law, and serving as counsel to trade associations in the areas of health and safety, the environment, and the manufacture and transport of explosive products.

KENNETH M. PERDUE

Kenny has been active in the AFL-CIO and central labor councils since 1977, and an active member of the Sheet Metal Workers International Association for over 30 years. He was elected to the West Virginia AFL-CIO's executive board following the retirement of his father from the board in 1989. A second-generation union sheet metal worker, with three brothers also working in the trade, he was elected as a business representative for his local union. He served as secretary-treasurer of the West Virginia AFL-CIO from 1997 until August 16, 2004, when he became president upon the retirement of the former president.

REBECCA RANDOLPH

Rebecca McPhail Randolph is the president/CEO of Vision Shared. Prior to Vision Shared, Randolph served as the assistant vice president for development at Marshall University, located in Huntington, WV. Prior to working for Marshall, Randolph was director of development at the University of Charleston in Charleston, WV. Before returning to West Virginia in 2003, Randolph served as grant development and research manager and interim director of development for the YMCA of Greater Cleveland in Cleveland, OH. She has also worked for nonprofit health care organizations in both West Virginia and Ohio and as a development consultant in northeast Ohio. Randolph earned her bachelor's degree from the West Virginia Institute of Technology. She and her family reside in Huntington.

L. JEREMY RICHARDSON

Jeremy is a senior energy analyst at the Union of Concerned Scientists. At UCS, he has explored the fundamental cultural and economic drivers of coal production in West Virginia and identified ways of creating diverse economic opportunities. His work seeks to understand the deep connection people have with coal, to quantify the changing economic importance of coal to local populations, and to develop actionable paths to build local support for a more economically and environmentally sustainable future. He seeks to bridge the gap between the national and regional/state-level policy discussions about our energy future. In addition to coming from a coal mining family in West Virginia, Jeremy is a physicist who is passionate about the urgent need to address climate change. He received his PhD and MS in physics from the University of Colorado at Boulder and has a BS in physics from West Virginia University.

SENATOR JAY ROCKEFELLER

Senator Jay Rockefeller has proudly served the people of West Virginia for nearly 50 years. Rockefeller first came to West Virginia in 1964 as a 27-year-old VISTA volunteer serving in the small mining community of Emmons. Many of the lessons that Rockefeller learned in Emmons have shaped his public service career and led to his lifelong commitment to improving the lives of West Virginians and all Americans. Senator Rockefeller is the chairman of the Senate Committee on Commerce, Science, and Transportation. He is also the chairman of the Health Care Subcommittee on the Senate Finance Committee, and a member of the Senate Select Committee on Intelligence. He also serves on the Senate Committee on Veterans' Affairs.

Rockefeller was born on June 18, 1937. He graduated from Harvard University in 1961 with a BA in Far Eastern languages and history. In 1964, he came to Emmons, WV, where he began his public service career serving the people of West Virginia. In 1966, he was elected to the West Virginia House of Delegates and to the office of West Virginia secretary of state in 1968. He served as president of West Virginia Wesleyan College from 1973 to 1976. In 1976, Rockefeller was elected governor of West Virginia, and was re-elected in 1980. In 1984, he was elected to the United States Senate, and re-elected in 1990, 1996, 2002, and 2008. Since 1967, Rockefeller has been married to Sharon Percy Rockefeller with whom he has four children: John, Valerie, Charles, and Justin. Jay and Sharon are also the proud grandparents of four granddaughters and two grandsons.

SCOTT ROTRUCK

Scott Rotruck recently retired as vice president of corporate development and state government relations for Chesapeake Energy Corporation. He spent 10 years in the railroad industry with CSX Corporation and Norfolk Southern Corporation. He spent 15 years in the energy sector with Anker Energy and CONSOL. He served as the economic development director and senior adviser to the president at WVU and worked for the WVU Extension Service. He served a term as chairman of the WVU Extension Service Visiting Committee. Scott was chairman and CEO of the Morgantown Area Chamber of Commerce. He is the past chairman of Vision Shared, West Virginia Tourism Commission, the West Virginia Council for Community and Economic Development, WVJIT, and the Interstate Commission on the Potomac River Basin in 2000. Scott served on task forces for the Cheat River and the North Branch of the Potomac River, which runs through his hometown of Keyser, WV. He served on the University of Charleston's board of trustees and is a board member of Imagine Greater Pittsburgh. He is a 1977 West Virginia University graduate and holds an MBA from Frostburg State University. Scott and his wife Carol, who is from New Martinsville, WV, have three adult children: Sarah, Jill, and Ethan.

DAVID SATTERFIELD

David Satterfield is currently the director of asset development for the Office of Research and Economic Development at West Virginia University and a tenured associate professor in the School of Music. Mr. Satterfield also serves as the interim president of the WVMEP as well as the associate director of the Center for Excellence in Disabilities. David Satterfield served as the executive director of the West Virginia Development Office from October 2001 through January 2005. Prior to joining the Development Office Mr. Satterfield served as the chief of staff and vice president for institutional advancement at West Virginia University. Satterfield is a native of Pittsburgh, PA. He earned two music degrees (BM and MM) from WVU and has been a faculty member in the College of Creative Arts at WVU since 1983. Satterfield and his wife, Beth, a faculty member in the College of Human Resources and Education at WVU, have two children: Keith and Allie.

JAMES SKIDMORE

James L. Skidmore became the first chancellor for the Community and Technical College System of West Virginia. Prior to that, he served as vice chancellor for community and technical college education with the Higher Education Policy Commission. Mr. Skidmore, a West Virginia native, has served higher education in West Virginia for over 20 years, with positions at WVU Institute of Technology, West Virginia State University, and the Higher Education Central Office. He serves on numerous state-level workforce development committees and has led initiatives that have positively impacted the delivery of workforce development programs in West Virginia. As chancellor, he serves as chief executive officer of the WV Council for Community and Technical College Education, the state-level coordinating body for community and technical college education.

KENT SPELLMAN

Kent R. Spellman brings a diverse background to his work as executive director of the West Virginia Community Development Hub. For 20 years, he owned and was president of Rooftree, Inc., a design/build construction company based in Harrisville, WV, specializing in high-end residential and light commercial projects. In 1996, he became editor, publisher, and part owner of the *Ritchie Gazette*, a weekly county newspaper serving Ritchie County. While at the *Gazette*, Kent won 31 WV Press Association individual awards for reporting, editorials, photography, and advertising design; the *Gazette* was repeatedly named the best newspaper in the state in its division. Kent has been recognized as a Distinguished West Virginian by Governor Cecil Underwood, and as an Honorary WV State Trooper—at the time only the fourth person in State Police history to receive such recognition. He lives in Clarksburg with his wife Betsy.

NATALIE E. TENNANT

Natalie E. Tennant is West Virginia's twenty-ninth secretary of state. Throughout her administration, she has been a leader in promoting open and engaging government and business-friendly initiatives. Tennant has streamlined the Secretary of State's Office to make it more efficient and cost-effective while improving services for voters, candidates, business owners, and citizens. Most recently, Secretary Tennant spearheaded legislation to allow for online voter registration in West Virginia. West Virginia has also emerged as a leader on the national stage when it comes to making it easier for deployed military to vote using a safe and secure Internet connection. Along with her duties as secretary of state, Tennant was the first West Virginian chosen for the Aspen Institute's Rodel Fellowship program. In 2012, Secretary Tennant was elected to another four-year term. Secretary Tennant currently resides in Charleston with her husband, State Senator Erik Wells, and daughter, Delaney.

BETH VORHEES
You hear Beth Vorhees on the radio every morning and during the legislative session, you see her on TV every evening. Beth is the producer and host of *West Virginia Morning*, heard every weekday morning at 7:30 on West Virginia Public Radio. You also hear her deliver the news throughout the morning on *Morning Edition*. When the state legislature is in its 60-day regular session, Beth is the producer and host of *The Legislature Today* on West Virginia PBS. Beth is the director of news and public affairs at West Virginia Public Broadcasting, leading an eight-person news team with bureaus across the state. Beth lives in Charleston and has been married to Rick Vorhees for 31 years. They have one daughter, Diana, of Nashville, TN.

JOHN WEETE
Dr. Weete joined the Auburn Research and Technology Foundation (ARTF) as its executive director on September 1, 2007. The ARTF is responsible for the overall development and operation of the Auburn Research Park located on the Auburn University campus. Previously, Dr. Weete served as the vice president for research and economic development at West Virginia University and president of the West Virginia University Research Corporation. He received his BS and MS degrees at Stephen F. Austin State College in Nacogdoches, TX, and PhD at the University of Houston. He was a post-doctoral fellow at the Baylor College of Medicine and visiting scientist at the Lunar Science Institute in Houston, TX, prior to joining the faculty at Auburn University.

MATT WENDER
Commissioner Wender is the public sector representative for Fayette County. He is a CPA who holds a bachelor's degree in business administration and an MBA from West Virginia University. Matt recently retired from West Virginia Jobs Investment Trust, where he served as investment manager since 1998. WVJIT manages the state's Venture Capital Fund with a portfolio of investments and funds in excess of $26 million. WVJIT has a statewide presence, with a current portfolio of 21 companies in a wide range of industries including manufacturing, software development, biomedical, and insurance. He represented WVJIT on several boards of directors. Before joining WVJIT, he was employed by a privately held venture capital firm for two years.

CHRIS YURA
Chris Yura is founder and chief executive officer of SustainU. As CEO, Chris is responsible for leading the company and overseeing all aspects of its business development initiatives designed to achieve long-term growth. Prior to launching SustainU, he gathered and developed his experience in the fashion and entertainment industry while based in New York City, while maintaining his interest and involvement in social and environmental-related issues. Previously, he served in managerial roles within the customer service field, developing marketing strategies and strategic business initiatives to attract prospective clients. Chris attended the University of Notre Dame where he was a four-year letterman and standout fullback for the Fighting Irish football team, and received a bachelor of arts degree in sociology and computer applications.

[APPENDIX D]

Excerpts of Selected Media Coverage of the Forum

INNOVATORS, ENTREPRENEURS, POLICY EXPERTS MEET AT ECONOMIC ...

West Virginia Public Broadcasting-September 5, 2013
While the Union of Concerned Scientists usually focuses on issues related to climate change and renewable energy, West Virginia native and UCS Fellow ...
http://www.wvpubcast.org/newsarticle.aspx?id=31510

McDOWELL RESIDENTS TELL STORIES OF STRUGGLES, SUCCESSES

Charleston Gazette-September 4, 2013
Forum organizer Jeremy Richardson of the Union of Concerned Scientists said that "Hollow" fit in perfectly with the event, which partly aimed at trying to . . .
http://www.wvgazette.com/News/201309040304

BUSINESS LEADERS: W.VA. MUST EMBRACE ECONOMIC CHANGE

Charleston Gazette-September 4, 2013
The event, sponsored by the West Virginia Center on Budget and Policy, the Union of Concerned Scientists and the West Virginia Community Development Hub, . . .
(Note: this article appeared on the front page of the print edition.)
http://www.wvgazette.com/News/201309040053

"FUTURE FUND" PUSHED TO DIVERSIFY ECONOMY

Charleston Gazette-September 4, 2013
The event is sponsored by the Union of Concerned Scientists and the West Virginia Center on Budget and Policy and aims to highlight and foster discussions of . . .
http://www.wvgazette.com/News/201309030156

NOT YOUR GRANDFATHER'S ECONOMY ANYMORE (EDITORIAL)

Daily Mail Charleston-September 6, 2013
Sounds like there was a lot of good discussion by intelligent people at the forum. Thanks to the sponsoring organizations, which also included the Union of Concerned Scientists and the West Virginia Community Development Hub, for pushing the economic diversity discussion in West Virginia.
http://www.dailymail.com/Opinion/Editorials/201309060046

FORUM FOCUSES ON POSSIBLE FUTURE OF W.VA. ECONOMY (AP ARTICLE THAT APPEARED IN DOZENS OF STATE NEWSPAPERS)

Businessweek-September 3, 2013
The Union of Concerned Scientists is teaming up with the West Virginia Center on Budget & Policy and others to present panels on several topics.
http://www.businessweek.com/ap/2013-09-03/forum-focuses-on-possible-future-of-w-dot-va-dot-economy

ORGANIZER OF ECONOMIC DISCUSSION HOPES EVENT SPARKS DIALOGUE

Daily Mail Charleston-September 2, 2013
Jeremy Richardson, a fellow at the Union of Concerned Scientists in Washington, D.C., hopes to change that with his event "A Bright Economic Future for the . . .
http://www.dailymail.com/News/statenews/201309010110

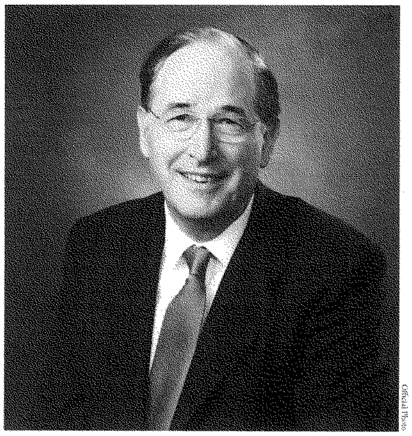
MEETING TO FOCUS ON W.VA. ECONOMIC DIVERSITY

Charleston Gazette-August 28, 2013
Promotional materials for the forum, called "A Bright Economic Future for the Mountain State," don't mention climate change or the coal industry's ongoing decline. But those issues and their impact on coalfield communities are really the backdrop for the event, sponsored by the Union of Concerned Scientists . . .
http://www.wvgazette.com/News/201308280149?page=1

[APPENDIX E]

Senator Jay Rockefeller's Prepared Remarks

SEPTEMBER 4, 2013


Official Photo

Today is an exciting gathering of brilliant minds and energetic spirits who are bound by the belief and knowledge that the sky is the limit for our state.

West Virginia is poised to do great things and our conversations today will help us expand our dreams and visions for tomorrow.

I have always believed that our actions must be guided by the larger impact they'll yield in the future. We must be working, planning, and acting now for the West Virginia we want in 10 years, 50 years, and even her next 150 years. And we can.

America is innovation. It's the very essence of our country—to invent, to solve big problems, to take things to the next level.

We've been the first to do everything from inventing flight to putting a man on the moon, from developing computers to creating endless possibilities with the Internet.

And here in West Virginia we are champions of innovations. Golden Horseshoe winners can tell you about James Rumsey, who built the first steamship and piloted it down the Potomac River in Shepherdstown.

More recently, researchers at the Green Bank Observatory have stretched the very boundaries of our universe, pioneering new techniques that allow astronomers to listen deeper and deeper into space.

And NOAA (the National Oceanic and Atmospheric Administration) is building a remarkable system that supports the nation's next generation of geostationary weather satellites, helping us better predict severe weather and creating highly skilled jobs here in West Virginia.

North-central West Virginia's economy is booming, with a high-tech economy powered by innovation, and just down the road here, our cutting-edge technological advances in chemicals and polymers are second to none.

Paired with our American spirit of innovation, our unmatched West Virginia work ethic creates an enormously powerful combination. So what other ingredients do we need to launch into a bright future? One is investment in key education and training efforts.

That was the goal of the original AMERICA COMPETES Act in 2007, and its reauthorization in 2010. As chairman of the Senate Commerce Committee, I have been able to steer this important law through Congress.

America COMPETES was born at a time when there were warning signs that America's position as a global leader in science and technology was at risk. From the outside, it looked as if our country was beginning to lose its way in encouraging innovation at all levels.

We were not doing enough to educate and train our youngest generations for the new global economy. We worried that our students were falling behind.

The idea to put our country back on the right track was simple: increase science and research investments.

Strengthen education in the STEM disciplines: science, technology, engineering, and mathematics. Develop an innovation infrastructure. Give our children and grandchildren the tools and resources they will need to compete in the global economy.

But those are big picture ideas. How do they translate in real terms to West Virginia?

We all know West Virginians are the hardest working people in the country. We are ready for opportunity. And that's what COMPETES provides. It lays a foundation for new, high-tech economic opportunities.

High-tech jobs, like those flourishing in north-central West Virginia and nearby at the South Charleston Tech Park, pay significantly more than the average private sector job.

These desirable and highly sought-after jobs lead to successful careers, and they produce the solutions of the future that meet big challenges. These important jobs require advanced training, and we need to be sure that workforce is readily available in all of our communities.

Just look at the numbers. Between 1995 and 2007, high-tech jobs in STEM fields accounted for nearly 40 percent of U.S. GDP and 30 percent of the world's GDP in 2007. As a result, the number of STEM jobs has grown three times faster than non-STEM jobs over the past decade.

Projections for the next decade indicate that STEM occupations will grow by 17 percent, compared to 9.8 percent for other occupations. STEM workers earn 26 percent more on average and are also less likely to be unemployed.

This is where COMPETES comes in. With the resources and opportunities that COMPETES provides, workers can get the retraining and education necessary to fill these high-tech jobs because many here know sometimes difficult and time-consuming process to find or retrain skilled workers.

And it funds science and research programs that create even more high-tech jobs in the long term.

At the same time, we need to take the lessons learned from COMPETES and apply them to how we are educating our young students so they can realize the full potential of their bright futures.

Science, technology, engineering, and math experience will be vital to the next generation's success. COMPETES gives students a fighting chance. It gives them the resources and tools today for the jobs of tomorrow.

COMPETES secures our state's future. It gives us the opportunity to make sure that the high-tech jobs that are multiplying in West Virginia continue to spread to every part of our state.

So as the Commerce Committee begins the process of reauthorizing the America COMPETES Act this fall, I look to each of you for support.

Be champions of innovation in your community. Support entrepreneurs who understand the realities of our new economy. Challenge your school systems and administrators and teachers to ask more of their students. Encourage your children to take their place in our exciting, high-tech world.

It seems obvious to most in this room that securing our future would be a simple choice. That educating our children so they can grow up in the global economy with a fighting chance would make sense.

But I assure you that not everyone sees it this way. That's why all of you are so important.

We also need your help more practically. We are currently preparing to introduce a COMPETES reauthorization bill, but Congress is deeply, terribly divided. And we're dealing with the sequester, and some lawmakers who don't recognize the value of strategic, targeted investment.

So this fall, when we introduce the bill, each of you needs to call your elected officials—especially those in the House—and tell them how important these investments are.

You are the ambassadors, and it's your voice we need to hear as, in the next few months, we will need to increase the investments in science and research so more high-tech jobs are created.

We need to increase investments in training so these jobs can be filled by high-skilled workers. We need to educate more of our students in STEM fields so they have the backgrounds to thrive in the global economy.

And we will need to spur innovation in this country so the leaps and bounds that America has created are just the beginning of what's to come.

Union of Concerned Scientists

FIND THIS DOCUMENT ONLINE: www.ucsusa.org/WVbrightfuture

The Union of Concerned Scientists puts rigorous, independent science to work to solve our planet's most pressing problems. Joining with citizens across the country, we combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe, and sustainable future.

NATIONAL HEADQUARTERS
Two Brattle Square
Cambridge, MA 02138-3780
Phone: (617) 547-5552
Fax: (617) 864-9405

WASHINGTON, DC, OFFICE
1825 K St. NW, Suite 800
Washington, DC 20006-1232
Phone: (202) 223-6133
Fax: (202) 223-6162

WEST COAST OFFICE
2397 Shattuck Ave., Suite 203
Berkeley, CA 94704-1567
Phone: (510) 843-1872
Fax: (510) 843-3785

MIDWEST OFFICE
One N. LaSalle St., Suite 1904
Chicago, IL 60602-4064
Phone: (312) 578-1750
Fax: (312) 578-1751

WEB: WWW.UCSUSA.ORG

PRINTED ON RECYCLED PAPER USING VEGETABLE-BASED INKS

© NOVEMBER 2013 UNION OF CONCERNED SCIENTISTS

Senator CAPITO. Thank you, Dr. Richardson.

Our next witness is James M. Van Nostrand. Did I say that correctly?

Mr. VAN NOSTRAND. Van Nostrand, Senator.

Senator CAPITO. He is Associate Professor, Director of the Center for Energy and Sustainable Development, West Virginia University College of Law.

Welcome.

STATEMENT OF JAMES M. VAN NOSTRAND, ASSOCIATE PROFESSOR AND DIRECTOR OF THE CENTER FOR ENERGY AND SUSTAINABLE DEVELOPMENT, WEST VIRGINIA UNIVERSITY COLLEGE OF LAW

Mr. VAN NOSTRAND. Thank you very much, Senator Capito and Congressman Jenkins. I really appreciate the opportunity to speak today.

Before I start off, I want to share your frustration with the inability to get anybody from EPA to come to this State. We had a conference back in February 2014 focusing on the then anticipated EPA 111(d) Rules. Senator Manchin was our keynote speaker. We tried for weeks to get an EPA speaker to come to our conference. We started off with Janet McCabe and kind of kept working our way down. And we were unsuccessful in having them come to our State. So it is frustrating.

As everyone knows, we have a big basketball game coming up on Thursday night in Cleveland, Ohio. I thought today would be a good chance to not only talk about the Wildcats and the Mountaineers on the court, but let's talk about West Virginia versus Kentucky. I guess I would call my testimony a tale of two States; why West Virginia is losing the battle for our energy future.

In Kentucky—I think we all saw the Senate race last year where Senator McConnell and Alison Grimes were fighting about who hated the EPA the most. Most recently, Senator McConnell encouraged States to not cooperate with the EPA in the implementation of the 111(d) Rules. So we have that going on at one level.

But within the State of Kentucky, there's a tremendous bipartisan effort going on led by Governor Steve Beshear, a Democrat, and Congressman Hal Rogers, a Republican.

Several years ago, Governor Beshear started on a policy of an all-of-the-above energy strategy in the State of Kentucky. And most recently, he and Congressman Hal Rogers have encouraged the SOAR project which is shaping our Appalachian region. 1700 people showed up for the SOAR convention in Pikeville, Kentucky on the issue of the 111(d) Rules. They were basically talking about the future of Kentucky, moving toward a different future and having a broad bipartisan support taking on these tough issues of a transition.

On the 111(d) Rule, Kentucky was one of the leading States in the country. They shared a white paper with the EPA in October 2013 saying we know these rules are coming down the road and this is what's going to work for Kentucky. These are the things that we need to make this rule work for Kentucky. We are going to have a disproportionate impact, but these are the rules. Kentucky became a national leader in terms of a State getting out in front on the 111(d) Rules. We invited John Lyons, the head of the Energy and Environment Cabinet for Kentucky, to come to our conference back in February a year ago.

Now let's look at West Virginia. We have no comprehensive energy planning in this State. Our legislature just recently repealed the renewal portfolio standards, which would have encouraged renewal energy. They are rolling back net metering. And while many utilities around the country were selling off their coal plants for pennies on the dollar, in West Virginia we're buying additional coal plants and putting them into our rate base and actually paying more than their fair market value for them.

I understand Charles Patton is talking about the interest of AEP and diversity. Well, we're not seeing that diversity in West Virginia. The AEP subsidiary, Wheeling Power, just acquired the Mitchell plant. The AEP subsidiary, Appalachian Power, just acquired the Amos plant. Mon Power acquired the Harrison plant. These are all plants—for our foreseeable future, most of our electricity is going to be generated by coal. We're not seeing any event—any fuel diversity. We're not seeing any of the effects of the shale gas revolution.

We're not really sharing in those lower energy prices. Both utilities operating in West Virginia filed for double-digit rate increases last year. And that's before we get to the impact of these coal plants being added to our rate base and the increase in compliance caused under MATS and of the 111(d) Rules.

Our response on a legal front is, our attorney general has filed a lawsuit joined by 11 other States to destroy the EPA rule in court. We've joined the Murray Energy lawsuit. I don't think the courts are going to be able to stop climate change, and I don't think litigation is a climate change strategy, as a compliance strategy.

What's frustrating is it doesn't need to be this way. As Jeremy Richardson just mentioned, I think West Virginia has tremendous potential. We are sitting on top of the Marcellus shale. We are an energy State. We should be winning the energy war. We have more resources at our disposal than does Kentucky with the availability of natural gas, renewables. We have virtually untapped energy efficiency. We are rated number 46 in the Country by the American Council for Energy Efficient Economy in terms of our energy efficiency commitment. And we can do better.

As my testimony mentions, I think the whole issue of reducing greenhouse gas emissions really cries out for a legislative solution. I don't think the Clean Air Act is a great fit. I have concerns about 111(d), and I certainly have concerns about 111(b) that cries for a legislative solution. But I don't know that we're going to be able to get that solution. We're doing the best—I think the EPA is moving forward with the statutory authority on the Clean Air Act. They have the authority to do that.

But a legislative solution would be better because there's no question West Virginia is getting hit disproportionately hard. But there's limitations on what an agency can do to address those desperate impacts. A legislative solution could address that.

In closing—I don't know how the Mountaineers are going to do Thursday night. I'm very hopeful we'll be competitive. I think on the basketball court we'll be competitive. I worry that on the energy front, West Virginia versus Kentucky, I worry that we're losing that war. And we should be winning that war.

Thank you very much.

[The prepared statement of Mr. Van Nostrand follows:]

Testimony of James M. Van Nostrand

Associate Professor and Director, Center for Energy & Sustainable Development
West Virginia University College of Law

U.S. Senate Committee on Environment and Public Works
Field Hearing in Beckley, WV
March 23, 2015

"Regional Impacts of EPA Carbon Regulations: The Case of West Virginia"

My name is James M. Van Nostrand. I am an Associate Professor of Law and Director of the Center for Energy and Sustainable Development at the WVU College of Law. The Center is an energy and environmental research organization founded in 2011. The Center focuses on promoting practices that will balance the continuing demand for energy resources—and the associated economic benefits—alongside the need to reduce the environmental impacts of developing the nation's natural resources. I appreciate the opportunity to provide testimony at this field hearing regarding the regional impacts of carbon regulations proposed by the U.S. Environmental Protection Agency (EPA).

We have been following closely the actions of the EPA in regulating greenhouse gas (GHG) emissions from power plants. The Center's third annual national energy conference, held in February 2014, focused on the then-anticipated proposed rules under 111(d) of the Clean Air Act. The conference, titled "Regulation of CO_2 Emissions from Power Plants: Flexibility and the Path Forward for Coal Dependent States," brought together representatives from government, industry, labor, academia, and the environmental community for a day-long discussion about challenges and opportunities for coal dependent states. In June, the Center announced its "Carbon Dioxide Emission Reduction Opportunities for the West Virginia Power Sector" project. The project is part of a broader Center initiative to support constructive dialogue around energy policy choices in West Virginia that would enhance economic opportunity, reduce the environmental impacts of energy development, and put West Virginia on track to meet its CO_2 emission reduction obligations under the proposed rule.

In October 2014, the Center, in conjunction with Downstream Strategies and with funding provided by the Appalachian Stewardship Foundation, released a discussion paper (*Center Discussion Paper*) previewing a preliminary analysis of one potential Compliance Scenario for West Virginia under the proposed Clean Power Plan.[1] My testimony draws from the analysis in the *Center Discussion Paper*, and also identifies important challenges and opportunities facing West Virginia with respect to compliance with the proposed rule. My testimony also reviews important economic drivers in West Virginia that will be affected by the rule, as well as some of the key emission reduction measures that could put West Virginia on track to meet its goals as proposed by the rule.

---

[1] *Carbon Dioxide Emission Reduction Opportunities for the West Virginia Power Sector*, CENTER FOR ENERGY & SUSTAINABLE DEVELOPMENT (Oct. 2014) [hereinafter CENTER DISCUSSION PAPER] *available at* http://energy.law.wvu.edu/r/download/201008.

Climate Change and the Regulation of Greenhouse Gases under the Clean Air Act

Climate change, largely attributable to increasing concentrations of GHGs in the atmosphere, is the most serious threat facing the planet. The National Climate Assessment, for example, presents compelling evidence of long-term climate trends, and the likely future for the remainder of the 21st century, if we fail to take action to reduce GHG emissions. Within the state of West Virginia, we are already seeing some of the impacts of climate change, as discussed last June at a conference presented by the Friends of Blackwater. In my view, doing nothing to address this urgent problem is not an option.

At the same time, the Clean Air Act is a blunt instrument with which to regulate GHG emissions from power plants. The tools available to the EPA under the Clean Air Act to regulate GHGs do not provide a great fit for dealing with climate change; the regulation of GHGs would be better addressed through comprehensive energy and climate legislation, given the broad and disparate impacts on the economy and the ability through the legislative process to craft a solution that addresses the disparate impacts. Coal producing states like West Virginia will be especially hard hit, and the EPA lacks the statutory authority and financial resources to help the disproportionately impacted regions to attract new investments, or diversify their economy to minimize the economic and social impacts of the decline in demand for coal. In contrast, the comprehensive legislation passed by the U.S. House of Representatives in June 2009, while flawed in many respects, would have provided resources to address the disproportionate impacts felt across the country. For example, that legislation would have increased funding for the Energy Worker Training Program, which was created as part of the 2007 energy bill. Workers displaced due to new emission regulations would have been entitled to 156 weeks of income supplement (70 percent of their average weekly wages), 80 percent of their monthly health-care premium, up to $1,500 for job-search assistance, and up to $1,500 for moving assistance. Grants were authorized for colleges and universities to develop programs of study that prepare students for careers in renewable energy and energy efficiency.

In many respects, the EPA's actions in regulating GHGs from new and existing power plants are a result of the failure of the legislative branch to develop any comprehensive strategy for addressing climate change. We are therefore left with the tools available under the Clean Air Act. There is no question that the EPA has the legal authority to regulate GHGs as a pollutant under the Clean Air Act, following the decision of the U.S. Supreme Court in *Massachusetts v. EPA* (2007) and the subsequent endangerment finding by the EPA in 2009. The proposed rules under 111(b) for new power plants and under 111(d) for existing power plants are the result of actions EPA was required to take under the Clean Air Act after *Massachusetts v. EPA*.

The practical effect of the proposed rules under 111(b) may preclude the construction of a new coal plant in the U.S., given that the target emission rates for coal-fired plants can be achieved only with carbon capture and sequestration (CCS), which is a very costly process. The unlikelihood of new coal plant construction in the future has serious implications for the coal-producing regions of the country, including West Virginia. The future domestic demand for coal, simply stated, is being curtailed, thereby leading to the push for new coal export terminals on the coasts to serve foreign markets for U.S. coal. There is a legitimate question as to whether CCS technology is commercially available, and whether it is lawful for the EPA to effectively preclude a particular electric generation technology (i.e., coal) on the basis of an abatement technology that may not yet be readily deployable (or, alternatively, that is so expensive as to render coal uncompetitive with other fuels). The Kemper County Energy Facility in Mississippi, cited by the EPA as evidence that CCS is commercially available, has been plagued by cost over-runs and schedule delays. Another project cited by EPA, the Boundary Dam project owned by Sask Power in Canada, captures 90% of its CO_2 emissions, but has the unusual feature of having opportunities for enhanced oil recovery located nearby.

At the same time, it is not clear that the EPA proposed rule under 111(b) is the major deterrent for new coal plants in the U.S. If industry and EPA estimates of the regulatory impact of the proposed rule are true, no new coal-fired plants would have been built anyway, given the significant cost advantage that natural gas has over coal, both currently and based on long-term projections. The experience of the Longview plant north of Morgantown—the cleanest and most efficient coal plant at the time it was built—demonstrates the challenges of coal plants competing against natural gas-fired generation in the wholesale power markets. Cheap natural gas has driven down wholesale power prices to the extent that, while the Longview plant may still be competitive in the wholesale power markets, the margins it makes on each sale are so low as to threaten its financial viability.

Impact of EPA Carbon Regulations on Energy Production

Coal fired power plants generated 39% of U.S. electricity in 2013, down from over 50% in 2005.[2] West Virginia generated approximately 96% of its electricity from 16 major coal fired power plants in 2012, with the remaining 4% coming (largely) from hydropower and wind.[3] Across the U.S., over 60 gigawatts of coal fired power plant capacity is scheduled to retire by 2016.[4] In West Virginia, 6 of the 16 coal plants operating in 2012, representing approximately 17% of the state's generating capacity, have either deactivated or are scheduled to deactivate by 2015.[5] At the time of deactivation, those plants will be on average over 60 years old. The national trend away from coal fired generation, and production declines in the Appalachian coal mining industry over the long-term, suggest that the broader socio-economic challenge for coal producing states is to prepare for a future that is less dependent upon coal—irrespective of the impact of more stringent environmental regulation. And while coal mining will continue to be an important part of West Virginia's economy for the foreseeable future, the state must look for additional drivers of economic development to mitigate the impacts of the decades-long decline in the coal industry. Efforts such as the Shaping Our Appalachian Region (SOAR) initiative that are underway in Kentucky provide a model for the kind of discussions and leadership from all levels of government that are needed to mitigate the long-term impacts of declining coal production and its associated socio-economic impacts in West Virginia.

---

[2] In 2013, coal provided 39% of U.S. electric generation, natural gas 27%, nuclear 19%, hydropower 7%, other renewable 6%, petroleum 1%, other gases <1%. *Frequently Asked Questions, What is U.S. Electricity Generation by Fuel Source?*, **U.S. ENERGY INFORMATION ADMINISTRATION**, http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3

[3] *State Electricity Profiles, West Virginia Electricity Profile 2012*, **U.S. ENERGY INFORMATION ADMINISTRATION**, http://www.eia.gov/electricity/state/westvirginia.

[4] *AEO2014 Projects more Coal-Fired Power Plant Retirements by 2016 than have been Scheduled*, **U.S. ENERGY INFORMATION ADMINISTRATION**, Feb. 14, 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=15031.

[5] CENTER DISCUSSION PAPER, *supra* note 1 at 4.

West Virginia is a leading energy state that is uniquely positioned to mitigate the impacts flowing from the proposed Clean Power Plan and stimulate new economic opportunity throughout the state. The EPA's use of "building blocks" to calculate the Best System of Emissions Reduction (BSER) in each state as part of its 111(d) rulemaking process provides a roadmap of the tools available to each state to achieve compliance with the Clean Power Plan. As a practical matter, the process should stimulate comprehensive energy planning in West Virginia, and the cooperation across state agencies—the Public Service Commission (PSC) and the Division of Energy, along with the traditional environmental regulator in the state, the Department of Environmental Protection—to develop a cost-effective strategy for West Virginia to achieve compliance with the proposed rule. In developing this strategy, West Virginia is in an excellent position to adopt an "all of the above" approach to our energy future.

In addition to its coal resources, West Virginia sits atop abundant natural gas resources in the Marcellus shale, has significant renewable energy and biomass potential, and virtually untapped energy efficiency resources. Despite the significant challenges facing West Virginia, the Clean Power Plan provides a framework through which West Virginia can align its energy policies to meet the required carbon emission reductions. The proposed rule offers flexibility for developing state plan frameworks that allow states to, for instance, coordinate with neighboring states in order to maximize cost-effective emission reduction opportunities, and incorporate other strategies in order to achieve important public policy goals. Taking advantage of these opportunities will stimulate new economic activity in regions of the state hit hard by declining coal production and ensure that its utilities are making investments that provide consumers clean, reliable, and reasonably priced electricity.

Impact of EPA Carbon Regulations on Electricity Generation and Cost

Utilities in West Virginia historically have not been required to prepare integrated resource plans (IRPs). This process, adopted in the vast majority of states, requires rigorous analysis of the various resource options available for utilities to meet the energy demands of their customers, and requires that supply-side and demand-side options be considered side-by-side, on a consistent and integrated approach. With the passage of a statute in the 2013 West Virginia legislative session requiring integrated resource planning,[6] the utilities in the state will soon be undertaking a more thorough energy planning process. In the short-term, however, the state is not well-positioned to cope with the consequences of the Clean Power Plan.

---

[6] HB 2803, codified at §24-2-19 of the West Virginia Code.

West Virginia's rate-regulated utilities have increased their dependence on coal-fired generation, by acquiring coal-fired generating facilities from affiliated companies during the past few years. Specifically, the West Virginia PSC has approved three transfers of coal-fired electric generating units into the regulated rate base in West Virginia (FirstEnergy's transfer of 80% of the Harrison generating plant to its regulated utility operating companies, AEP's transfer of the Amos Power Plant to its Appalachian Power affiliate, and AEP's transfer of a 50% interest in the Mitchell plant to its Wheeling Power affiliate). As a result of these investments, West Virginia ratepayers will likely bear higher compliance costs under the proposed Clean Power Plan, given the inability to avoid the costs of owning these plants while at the same time bearing the increased costs of pursuing opportunities under the third and fourth building blocks of the Clean Power Plan (*i.e.*, renewable energy and energy efficiency). In other words, when these power plants are "out of the market" in the competitive wholesale markets due to low wholesale power prices, any excess generating capacity freed up as a result of Clean Power Plan compliance strategies to expand energy efficiency programs and renewable energy resources will not likely produce wholesale revenues sufficient to offset the cost of ownership borne by ratepayers.

Developing a compliance strategy for the Clean Power Plan will require drawing upon all of West Virginia's energy resources, including natural gas, renewable energy, and energy efficiency, as discussed below. A comprehensive energy plan should build upon the state's coal resources—through co-firing natural gas with coal, building new natural gas combined cycle (NGCC) and combined heat and power (CHP, or cogeneration) capacity, for example—while stimulating investments in energy efficiency that will help West Virginians manage their energy costs and reduce CO_2 emissions.

Natural Gas

The Clean Power Plan recognizes the emission benefits of natural gas relative to coal. West Virginia has significant natural gas resources in the Marcellus Shale. Developing West Virginia's natural gas resources and investing in natural gas-based electricity generation will help the state comply with the Clean Power plan and grow the state's energy economy. Natural gas prices have declined dramatically in recent years due to technological breakthroughs that have unleashed unprecedented development of the nation's vast shale gas resources. The Marcellus Shale is one of the most prolific shale plays in the country and accounts for nearly 40% of total U.S. shale gas production. Pennsylvania and West Virginia are the largest producers of Marcellus Shale natural gas, and West Virginia has enormous opportunity to capitalize on expanded use of its natural gas resources. The construction of new NGCC plants, co-firing existing coal plants with natural gas, and building new CHP facilities would stimulate demand for West Virginia–produced natural gas, deliver consumers low-cost natural gas–fired electric generation, and provide emission-reduction benefits under the Clean Power Plan.

While recent acquisitions by West Virginia utilities may represent a step backward for reducing the state's CO_2 emission intensity, natural gas fired generation can play an important role going forward. One NGCC plant—the Moundsville station—is anticipated to go into service in West Virginia as early as 2018 and would provide 525 MW of high-efficiency natural gas generation capacity. This additional capacity would stimulate additional demand for West Virginia natural gas, provide much needed resource diversity, and reduce the emission intensity of the state's power sector.

Other high efficiency uses of natural gas include CHP facilities, which currently provide 82,000 MW of generating capacity at over 3,700 industrial and commercial facilities across the country. In addition to providing on-site generation for large customers, CHP facilities achieve substantial improvement in energy efficiency by using the waste heat that would otherwise be released to the atmosphere to heat and cool buildings or to meet thermal needs of industrial processes. CHP installations can use a variety of fuels, but natural gas is the most common and accounts for 72% of installed CHP capacity.

West Virginia currently has 382 MW of installed CHP capacity and has significant potential for future growth. The American Council for an Energy Efficient Economy (ACEEE) estimates approximately 1,700 MW of remaining technical potential for CHP in West Virginia and that 588 MW of that is economically viable if utilities in the state are provided additional incentives. (Without those incentives, ACEEE estimates that only 71 MW of additional CHP capacity is economically viable in West Virginia.) Facilitating the addition of new CHP capacity improves grid reliability, provides numerous economic benefits, stimulates demand for West Virginia-produced natural gas, and reduces the emission intensity of the state's power sector.

Renewable Energy

The Clean Power Plan recognizes the importance of renewable energy resources in reducing GHG emissions. Non-hydropower renewables—namely wind and solar—grew by nearly 300% nationally between 2005 and 2013 and have enormous potential for future growth. In EPA's calculation of BSER for West Virginia, it estimates that non-hydro renewable energy can produce 14% of West Virginia's total generation by 2030, contributing over 60% of the state's emission reduction goal. West Virginia generated approximately 4% of total electricity produced in the state from wind and hydropower in 2012, but has significant potential for new wind, solar, and biomass, and possibly some additional hydropower development by retrofitting existing locks and dams with turbine generators. Wind power currently accounts for approximately 2% of West Virginia's total generation and the Clean Power Plan proposes to count existing wind (and solar) energy toward compliance with a state's emission reduction goals. The Clean Power Plan proposes to allow states to take credit for renewable energy projects built either within their own state, or out of state, so long as those projects are built in response to a renewable energy policy in the state taking credit for that project. Developing West Virginia's renewable energy resources will contribute to the state's ability to comply with the Clean Power Plan, diversify the state's energy portfolio, grow the state economy, and create new jobs.

A study conducted by the Union of Concerned Scientists (UCS) concluded that the Clean Power Plan underestimates the potential for renewable energy to reduce power sector emissions on a national level, but that EPA projections for renewable growth within West Virginia may be higher than what is likely economically achievable by 2030.[7] Adopting the analysis conducted by UCS in the case of West Virginia, the Compliance Scenario presented in the *Center Discussion Paper* assumes that non-hydropower renewables grow to achieve 7% of West Virginia's total generation by 2030—half of the EPA goal—comprising 410 MW of new solar capacity and 2106 MW of new wind capacity by 2030.[8]

Energy Efficiency

Coal has long been the state's near-exclusive source of electricity and historically, West Virginia's coal plants have provided West Virginia consumers some of the lowest electricity rates in the country. While our *rates* may be low, however, West Virginia is among the top ten states in the country with the highest residential electricity expenditures as a percent of median income; and it has the highest residential energy consumption per household among the thirteen Appalachian states.[9] In other states, energy efficiency programs offer consumers the tools to manage their energy *bills*, regardless of their utility *rates*. The energy efficiency programs currently offered by the FirstEnergy and American Electric Power subsidiaries operating in West Virginia, however, are minimal, compared to the programs offered by these same companies' subsidiaries in surrounding states.[10] West Virginia's utilities can do much better with respect to energy efficiency.

Energy efficiency is a low-risk, low-cost energy resource that provides direct savings to consumers, encourages investment across other sectors of the economy, displaces the need for costly investments in new energy supply infrastructure, creates new employment opportunities, and reduces emissions of CO_2 and other harmful pollutants. States are increasingly recognizing the value of energy efficiency as an energy resource and adopting policies to facilitate its deployment. In 2013, eight of the top 10 states identified by ACEEE in its 2013 State Energy Efficiency Scorecard had adopted binding energy efficiency resource standards. West Virginia does not have an energy efficiency resource standard and ranked #46 in the Scorecard.

West Virginia utilities currently offer consumers very few energy efficiency programs compared to those offered by the same utilities operating in other states. For instance, in 2009, the West Virginia PSC approved the FirstEnergy subsidiaries' plan to achieve a cumulative energy efficiency savings of 0.5% over five years, or 0.1% per year. FirstEnergy subsidiaries in neighboring Pennsylvania are achieving much higher levels of savings, at 1% per year.

---

[7] Strengthening the EPA's Clean Power Plan, UNION OF CONCERNED SCIENTISTS (Oct. 2014) available at http://www.ucsusa.org/sites/default/files/attach/2014/10/Strengthening-the-EPA-Clean-Power-Plan.pdf.

[8] CENTER DISCUSSION PAPER, *supra* note 1 at 6.

[9] *Id.* at 4.

[10] *E.g.*, FirstEnergy subsidiaries Metropolitan Edison Co., Pennsylvania Electric Co., Pennsylvania Power Co., and West Penn Power achieved over 4% cumulative energy efficiency savings in their Pennsylvania service territories over a 5 year period running from June 2009 to May 2014 pursuant to Pennsylvania's Act 129. *See* FirstEnergy Corp, Pennsylvania Tariffs, https://www.firstenergycorp.com/customer_choice/pennsylvania/pennsylvania_tariffs.html.

The Clean Power Plan recognizes the potential for energy efficiency to provide significant GHG emission reductions from the power sector. As applied to West Virginia, the BSER assumes West Virginia can avoid 10.71% of in-state electricity consumption by 2030 through energy efficiency. Under this scenario, energy efficiency would contribute 17% of the state's emission reduction goal. Based on energy efficiency savings that utilities operating in West Virginia are achieving in surrounding states, in conjunction with estimates provided by ACEEE, the Compliance Scenario presented in the *Center Discussion Paper* assumes that West Virginia's could achieve cost-effective energy efficiency savings of up to 18% by 2030. Tapping into West Virginia's vast energy efficiency potential will be central to West Virginia's ability to meet the proposed emission reduction targets, provide West Virginia residents and businesses more control over their energy consumption, will lower their electric bills, and will make West Virginia a more attractive state for business to locate.

Conclusion

Achieving compliance with the Clean Power Plan would present significant challenges for West Virginia. Given the state's heavy reliance on coal-fired electric generation and the portion of the state's economy that depends on the coal extraction industry, West Virginia may bear a heavy burden associated with implementation of the Clean Power Plan, depending upon the extent to which the flexibility allowed under the Clean Power Plan is exercised. In order to minimize the impact of the proposed rule on the state, policymakers will need to take advantage of that flexibility to shape a strategy for West Virginia that reflects its unique circumstances and leverages its strengths. West Virginia is fortunate in that it has tremendous energy resources in addition to coal, and these other resources—including natural gas, renewable energy (wind, solar, hydropower), and energy efficiency—are relatively untapped. Developing a compliance strategy for the Clean Power Plan will require tapping into these other energy resources and crafting a comprehensive energy plan that will build upon the state's coal resources—through co-firing natural gas with coal, for example—while stimulating investments in energy efficiency that will help West Virginians manage their energy costs in addition to reducing CO_2 emissions.

Senator CAPITO. Thank you very much. And, boy, they did look good last night, didn't they?

Our final witness is Charles Farmer who is president of Rouster Rope, Wire and Rigging, a small business here in Raleigh County. Welcome, Mr. Farmer.

The process is basically a 5-minute synopsis of your testimony, and then we're going to move to the question portion. Welcome.

STATEMENT OF CHUCK FARMER, PRESIDENT, ROUSTER WIRE, ROPE AND RIGGING

Mr. FARMER. Thank you, Senator Capito, Representative Jenkins and panel. Thank you for having me here.

I hope I represent our State very well, but especially the southern part of West Virginia. Twenty years ago, I got into the rigging business for the logging industry. We saw them leave because of regulation insurance. We are not tied completely to the mining industry. But a devastating amount of loss of work has happened here.

The EPA MATS 111 regulations have an effect on small businesses which you generally don't see. We had over 170, 80 mines a year ago. Now we're down to 70, 80. We've lost a lot of revenue in our counties for road building particularly. I don't know how many of you have been between here and Kentucky, in Raleigh, Wyoming, McDowell, Mingo Counties and seen the absolute devastation of the economies and loss of business.

The EPA is making good headway, which we support, for clean air and the environment. In a regional timeframe, that would be good. But as they press harder and harder to adapt to stricter and stricter regulations, we see people leaving here, and a work force they are going to be very hard pressed to replace.

Our good customers, such as AEP, the United Mine Workers, and their workers and the mines here, have lost more than what we will. We've seen their plants—Clinch River, Glen Lyn, Kanawha River, Sporn. The regulations are pushing people out of work and leaving this industry. Our revenues are killing us.

My business is going down instead of going up in this wonderful economy that we have. I'm a petroleum engineer from West Virginia University. I've lived all over the world. I came back to West Virginia to make a difference in this community and to employ people in this town to try to make a difference and diversify our economy away from the extractive industries.

Again, I'll go back to the southern part of West Virginia. I don't know how many of you travel down there. But that's some of the steepest, roughest, uninhabitable terrain to build businesses, plants. Without removing the mountaintops, there is really no place to put people up out of the flood zone, not even to put the businesses here.

The infrastructure to get there—piping, water, electricity is extremely expensive to build that infrastructure here, which we support. The line transmission work, the gas and pipelines. But we continue to see interference. The delays and delays and delays of the projects, and the target moves and moves and moves, and the timeframe gets shorter. Our customers do not benefit from such haste to prove to the world—America is showing the way.

We had friends come back from China here in the past month in the coal industry. And they can tell you in their coal industry, they are running zero scrubbers on their plants. And we think this is an unfair advantage to the people whose economies are growing and ours are shrinking. It goes to all industries.

Now, 20 years ago, we had great hope for this place. But we see our customers moving down—Caterpillar left here this past year with 120 jobs in the mining equipment business. Our miners have had to become workers in the salt mines in Louisiana, and elsewhere. There is no work for them.

I hope that you will remember that the terrain here is not very conducive to building large plants and building new towns that are not actually in an area of danger from the environment that we continue to face.

When we got into the mining industry, there were so many tons of mines built. And through market forces and speculation, a lot of the mining grew. And like in the oil and gas industry now, our gas industry down here is going to be faced with regulations with the escape of methane. And I have drilled many wells.

When you get into productive gas well drilling, it's inevitable to get the gas away from the rig. It's a very dangerous situation. At some point in time, we feel like through these regulations, they're going to drive what is now a very expensive proposition—it takes $5 million to $6 million to drill one of these Utica/Marcellus wells. We can only imagine what the regulations are going to do to the gas drilling in Southern West Virginia. Our recounts are already in half. We are already seeing people going bankrupt and leaving the business because of market forces. But regulations are going to put a lot more pressure on them.

Again, we've seen our customers, such as this panel, spend billions of dollars to upgrade only to have the target moved again. The compliance efforts of these people have been Herculean. We applaud their efforts because we know the power companies are dedicated to finding a way to produce energy without coal. Without coal, I don't think our southern part of the State can survive in any way shape, form or fashion.

My contemporaries I work with do not think the Federal Government has any interest in the viability of this industry in the Appalachian basin. We feel like we're being put upon in an unfair competition against the world who does not adhere to what we're trying to do. We feel like their efforts—the Federal Government efforts should be to work with those people overseas to get some kind of equal playing field.

We're not asking for subsidies. Our company will diversify and continue to adapt. But to adapt is becoming an extremely difficult situation for Rouster Wire, Rope and Rigging. If a company here in town is spending $10,000 a month on energy and we get a 26 percent increase in energy, you're looking at one or two more employees that I could be putting to work. Take all the tax—I mean, off the dole and actually be constructive citizens of Southern West Virginia.

As we see our OEMs, our original equipment manufacturers, slow down—we're not talking about 4, 5, 10 jobs at Rouster Wire, Rope and Rigging. We're talking about hundreds of jobs from the ground to the top, to the finished product, to when that machinery goes into production. It's going to hurt our southern part of West Virginia worse than anything.

We do want a clean environment. Being fathers and grandfathers of children here, we definitely want a clean environment. We need consistent, long-term goals that don't crush our economy here in Southern West Virginia.

Thank you very much.

[The prepared statement of Mr. Farmer follows:]

Written Statement of Charles "Chuck" Farmer
Owner and President
Rouster Wire, Rope, and Rigging
Before the U.S. Senate Environment and Public Works Committee
Field Hearing
Beckley, WV
March 23, 2015

Impacts of U.S. EPA's Clean Power Plan on Small Business

Senator Capito, Representative Jenkins – Thank you for inviting me here today to speak about the devastating effects EPA's MATS and 111(d) regulations have had and will have on small business in West Virginia. You will hear supporters of EPA's regulations talk about the minimal impact these regulations will have on business. They will tell you that EPA is not responsible for the air of uncertainty that stifles investment and drives the downturn of the coal industry. They will tell you that businesses down here will simply just "adapt." I am here to tell you, as a small business owner, engineer, and West Virginian, that those statements could not be further from reality, or the truth. If you take the time to look around Southern West Virginia, you can see, first-hand, the impact these regulations are having on our communities. The closed shops, unemployed miners, and stagnant economic growth aren't just statistics – they are people.

I started Rouster Wire, Rope, and Rigging over 20 years ago with the goal of producing the most reliable and affordable wire, rope, and rigging for mineral extraction industries. My business provides the mining industry with safety slings for operations across the country. From Wyoming to West Virginia, we manufacture and repair the equipment that literally moves mountains to make sure Americans have affordable and reliable electricity. These tow slings are crafted by skilled laborers and generate substantial revenue for the company. Unfortunately, I have had to move cautiously with any new hiring or investments in production material because I am concerned about the impact EPA's regulations will have on the coal industry, my business, and my community.

When I got in to the mining equipment industry, business was good. In 1998, the coal industry produced over 180 million short tons of coal and I had to increase hiring to meet production demands. Today, total coal production in West Virginia has decreased to under 117 million short tons per year. Each year, as coal production decreases, I have to plan for the future and decided if I want to invest or save to avoid shutting down.

Anyone who has worked in the energy industry knows that everyone – from large corporations to small businesses – rely on credit to purchase expensive machinery. In order to make these investments, small businesses need certainty that EPA will not close their doors, or close the doors of their customers. Many of my customers have had to cut hours, freeze hiring, or lay-off employees altogether.

EPA's standards for new and existing coal-fired power plants expect electrical generating units to invest millions of dollars into updating their plants with unproven technology. These plants have no guarantee that EPA will not simply render their new technology "out of compliance" five years down the road. Power companies will be forced to pass these costs on to the consumer.

As an owner of a small manufacturing shop, I operate on margins where a crippling increase in energy bills would likely force layoffs or even shut us down. My business is already feeling the effects of EPA's Mercury Air Toxics Standards rule, and will certainly feel the brunt of 111(d). For example, say the monthly electric bill for Rouster Wire, Rope, and Rigging is $10,000. A projected 26% increase in electricity costs would add $2,600 to my electricity bill per month. That is $31,200 a year – A salary. How will I adapt? Will I sell more equipment? I won't be able – demand for mining equipment will decrease as decreased demand for coal shuts down mining operations. Further, my customers will feel the same rising electricity bills and won't be able to afford new equipment or repairs. I will be forced to lay off employees or close my doors after over 20 years of production.

Not only am I an engineer, but I have run a successful business for over 20 years; EPA academics regulating from behind a desk haven't. I grew up in Southern West Virginia, started my business in Southern West Virginia, and raised my family in Southern West Virginia. I want to stay in Southern West Virginia. EPA going forward with these regulations will force the entire coal industry out of business, and with it will go all of Southern West Virginia.

Senator CAPITO. Thank you, Mr. Farmer.

Thank all of you.

We're now going to move to the question portion. I am going to start—there's lots to talk about here.

I want to start with Mr. Patton. I want to talk about the reliability issue because coal is our baseload fuel in this country. And if we don't have the baseload, then we can't peak when it's really cold or it's really hot or where there's an outage or there's a flood or there's something that's happened in another region of the country that—or the region that is hampering our ability to get power.

And coal certainly is that baseload. It's secure. I read in your testimony where you can store it right on the facility. You don't have to look for it to come in maybe through a disrupted pipeline or something like that, or whether the sun is shining or the wind is blowing. It's there. Coal is there. It's solid.

Let's go back to the polar vortex of last year. I understand at AEP there were—that you were peaking at maximum capacity. If that were to happen in, say, 2 or 3 years from now when you've taken your coal plants down, it could have a real effect on the reliability of our power generation. Could you speak to that issue?

Mr. PATTON. Yes. Thank you, Senator.

So first of all, just one point of clarification to comments that were made previously about Appalachian Power Company. And it is related to your question.

Appalachian Power Company transferring coal plants to serve its customers in West Virginia. Yes, we did. I'm very proud of transferring those plants. Because those plants were the cheapest options for our customers.

It's important to understand in this conversation around natural gas—and natural gas is a rich, abundant resource. And it is the fuel—it is affordable fuel. It is. The price and availability of that fuel is indisputable.

The reality though is that if you have a coal plant and it is a coal plant that meets current EPA standards, that coal plant is very competitive with natural gas. Because coal on an MMBTU basis is still a cheaper fuel than natural gas.

The difference is the capital cost associated with building a new coal plant with all the environmental requirements versus the cost of building a new gas plant.

So the coal plants that Appalachian Power Company has transferred to serve its customers in West Virginia—or have been transferred because we believe that—to your question—that those plants are both reliable and they are affordable and the best option for our customers.

To that end, last year the polar vortex, which received a lot of attention—at Appalachian Power Company, we set an all-time peak. But what is not known for most people is this winter it did not get the attention of the polar vortex, but we broke last year's record. This February was actually colder than last year. Both last year and this year, every plant that Appalachian Power Company has—every coal plant was running—was up and operating.

The Glen Lyn plant, which will not be here next year. The Kanawha River plant, which will not be here next year. The Sporn plant, which will not be here next year. Cameron, which will not be here next year. All of these plants were running. I'm sorry. Not Cameron. But all of the APCO plants were running this year, and they will not be available next year or in the near future until we can build additional capacity.

The PJM, which is the governing body, tells us that they're at sufficient capacity. If there is sufficient capacity, why would we have to run every one of our units whenever we get into these peak conditions?

Senator CAPITO. I think that's a real concern certainly where the replacement for this power generation could possibly come from.

Just as a side comment, in your statement you talk about the cost of—well, you talked about it a little bit here—building a new coal-fired power plant, building a new natural gas plant. Well, it's not like these things can occur overnight either. What's the length of time—let's say you were going to—decided to build a natural gas plant in the Wheeling area. How long would that take—just real quick—expensive-wise and—a 10-year project?

Mr. PATTON. No. Once you get permits, I would say you could build one in probably—it's probably about a 3-year process.

Senator CAPITO. Once you get permits?

Mr. PATTON. Once you get permits.

Senator CAPITO. What's the time for the permit?

Mr. PATTON. Well, when I say 3 years—3 to 4 years, you can get permitted and build a natural gas plant.

Senator CAPITO. What is the approximate cost of something like that?

Mr. PATTON. A natural gas plant—to give you a common benchmark, a thousand megawatt gas plant would be about $1.3 billion.

Senator CAPITO. Mr. Trisko, let's talk about the EPA's legal authority that sort of came through everybody's testimony. You know that there's four building blocks. And for those of you in the audience, that's what the Clean Power Plan is based on, EPA's four building blocks. But building block one seems to fit within the EPA's traditional authority to regulate emissions at the source.

But is there any legal basis for EPA to regulate natural gas dispatch requirements?

What that means is, in this Clean Power Plan, they're saying—the way I understand it, the natural gas plant has to dispatch at 70 percent. Is that your understanding?

Mr. TRISKO. That's what the rule proposes.

Senator CAPITO. And presently they're dispatching at, what, 51 percent or something like that?

Mr. TRISKO. Yes.

Senator CAPITO. So do you think there is legal basis for the dispatch for the Renewable Portfolio Standard, or to order reductions in energy demand on customers?

Mr. TRISKO. Senator, those are all very good questions. Let me start at the top. Building block No. 1, the 6 percent efficiency improvement for coal plants. Even the author of the study that EPA relied upon for that 6 percent efficiency improvement has disclaimed the study for purposes of EPA's application of the study findings to this rule. Six percent has been roundly denounced in the comments EPA has received as being unachievable. The figures

I hear most commonly are in the order of 1 to 2 percent. It's realistic estimates.

Now, that would be an inside-the-fence reduction. That is what the UMWA urged EPA in a number of meetings that we held with the agency prior to the proposal of the rule. We said figure out what you can get from existing plants inside the fence. Send the engineers in, boots on the ground. Consistent with what EPA is required in its new source, Backed Guidance, by the way. And that went through an EPA stakeholder process for over a year. The agency chose to go far beyond the inside-the-fence approach.

Now, it starts with the natural gas dispatch requirement. To the extent that a coal-based facility has an existing gas combined cycle facility located within its fence line, then I would say arguably EPA has authority under Section 111(d).

But to the extent that another utility in another part of the State happens to have an existing natural gas combined cycle unit, then I don't see 111(d) as providing the authority for EPA to require that redispatch requirement.

Now, Senator, a key phrase in Section 111(d) is a standard of performance. Now, this is classic throughout the Clean Air Act, a standard of performance. I am at a loss to find within the penumbras of previous EPA regulation regarding existing source performance standards or new source performance standards requirements related to increased residential energy efficiency.

I am at a loss to find authority linking 111(d) to renewable energy standard requirements. There's good reason for that. Because under our Federal system, Congress has seen fit to allow the States to determine based upon their own individual social, economic, political characteristics the extent to which they would pursue energy efficiency programs or renewable energy standards.

As noted, West Virginia had its own renewable energy standard on the books for a period of time and just recently chose to repeal that standard. Other States similarly have moved in the direction of revising their renewable energy standards. Quite a number of States have chosen not to adopt them. This is an effort by U.S. EPA, in effect, to require those States that have chosen for their own reason not to pursue renewable energy standards to impose them under the rubric of Section 111(d).

I don't find the statutory authority for it. And I'm hopeful that the D.C. Circuit will likewise be doubtful of it, and ultimately the Supreme Court will affirm.

Senator CAPITO. Thank you.

Mr. Farmer, thank you for coming. Thank you for investing in West Virginia as a West Virginian. I think one of the most frustrating things for me is just the seeming inability for the EPA to actually look at what the economic impacts, you know, in regions has been. I just think that they have by the fact—as we shared, they haven't come and listened to us. They don't know about the thousands of miners that have already lost their jobs. Certainly, in Eastern Kentucky where Hal Rogers represents, they've had thousands of jobs lost there. And in Southern West Virginia, again, thousands of jobs.

Could you just—and you alluded to this in your statement. But I really would like to get on the record what your employees—how do they feel about knowing that they're on pins and needles as to whether they're going to have a job when they know that policies emanating from the President and the executive branch are really not listening to them, not seeming to even care, about what a particular region of this Country and how devastating policies that—as you said, tight timelines, unachievable deadlines. I mean, this has got to be a daily conversation in your building—buildings.

Mr. FARMER. Senator, I appreciate the opportunity to be here again. I again apologize for being late. 30 minutes before I was here, I looked like a coal miner. When Hampton called me, I had to rush and get a shower.

Our guys—we have a great, and have had a great work force here in Southern West Virginia that's provided energy and timber for our war efforts. I think that one common thread that runs through the conversation from the aggregate companies to the pipelining companies to transmission distribution and power generation, people are worried about the world situation here in this little part of Southern West Virginia. How would we prepare ourselves for a war to generate power and make steel, very energy consumptive, extractive base industries? We're the people that pick this stuff up. We're the people that get this off—materials on the cranes to pick these things up, to tie them down, to move them across our roads.

Our workers, Senator, are extremely worried of my ability to continue to provide jobs here in West Virginia which continue to shrink and contract. I don't think the world knows that much about our area down here and how rough it is. It's not—80 percent of the land south of Charleston is owned by large land-holding companies and coal companies and trusts. Eighty percent of the land north of Charleston is more held by private people.

There's no opportunity for my workers to turn and go across town and get a job for $13, $14 an hour. Our average salaries are $20, $25 an hour. Our bosses with no education make $65,000, $70,000 a year. These jobs are not here. The regulations that we see—we're intimately associated with the power generation, transmission, distribution business.

If I recall right, Mr. Patton, when you-all built the 765 KV line from Oceana to Jackson's Farm, Virginia—from the time of conception to the time of first caisson was drilled, it was like 10 years. I don't know if that's a fact or not.

Mr. PATTON. More like 14.

Mr. FARMER. Fourteen years from time of conception through the public comment period to constructing the first yard of gravel. By the way, that was our first large rigging job for my company. It gave me two more employees. And we thank you. But now, not only them, but we're worried about our gas line, which is what we're focused on this year.

We don't think that the regulations and—the permitting and the regulations that are going to be forced upon them through the EPA are going to allow us to continue—possibly not even be working here in 5 years. Thank you, Senator.

Senator CAPITO. Thank you. Congressman Jenkins.

Representative JENKINS. Thank you, Senator.

A couple of questions. First, Dr. Richardson, good morning and welcome. From your comments, I think I heard you say—and I just want to make sure. You think what the EPA has proposed is quote, not bold enough?

You think the EPA should actually be going further on their carbon and their greenhouse gas emission standards?

Mr. RICHARDSON. That's right. Thanks for the question.

If you look at the science of climate change and you look at the magnitude of the problem, it really is urgent to bring down our carbon emissions more so than what the proposed regulation would accomplish.

The analysis that we did at UCS shows that in terms of the renewables building block, that the agency actually underestimated the potential nationally for renewables to play a part in what they proposed.

Representative JENKINS. The progressive budget has for the last several years contained a provision for a carbon tax. And in the language in the progressive budget, it specifically says through the imposition of a carbon tax, it will have the ability to impact the weather and address significant storm potential.

Do you agree, one, with the belief that a carbon tax is a good mechanism by which to influence change, vis-a-vis electric power generation through the use of coal?

Do you support a carbon tax?

Mr. RICHARDSON. I would say that in general UCS's agnostic about the particular policy mechanism. But I think that we would absolutely agree that a price on carbon is essential.

I think that one of the most frustrating things for me is to hear people talk about how cheap coal is. Because if you look at the externalities from the extraction of coal, the transportation of coal, the burning of coal, the pollution that it releases when it's burned, the ash that's left over after it's burned—it has a huge impact on not only on the environment, but public health. And if you were to add up all of those extra costs that are not included in the price that you pay for your electricity, it would double or triple the price of coal-fired electricity.

So I think that the point of having a price on carbon would absolutely send a signal that, look, it shouldn't be free to dump this substance into the atmosphere.

Representative JENKINS. You raised during your comments, Williamson, West Virginia and held it out as a community leader in addressing health issues. Just in the last couple of weeks Williamson Hospital announced that they are going to stop delivering babies. No OB services in Williamson, West Virginia.

How do you look at a resident in Mingo County and an expectant mother who historically has gone to the local hospital, readily accessible, and faces now the impact of not being able to have a baby delivered in their own home community?

Mr. RICHARDSON. I think that if you—again, I'm from the northern part of West Virginia. I think that if you look at Southern West Virginia as a whole, there's a whole series of issues that come into play when we talk about the economy.

The subject of this hearing is just one of those things. Absolutely, there is an issue with the availability of health services. And healthcare in Southern West Virginia is a huge problem.

Representative JENKINS. As you tried to hold out Williamson as a leader in healthcare, transition or transformation, I'm just trying to provide a little reality check that this is a community and a people that are really struggling.

Mr. Van Nostrand, again, welcome to you.

Mr. VAN NOSTRAND. Thank you.

Representative JENKINS. You mentioned in your comments twice bipartisan in comparing Kentucky to West Virginia. I think you did it in a context of promoting—look what they're doing in Kentucky, bipartisan, bipartisan, twice.

We've got a Democratic Governor in West Virginia. And overwhelmingly within the West Virginia legislature, led by Republicans. Both Republicans and Democrats led the charge, again, signed by a Democratic Governor for the repeal of the renewable energy portfolio. Wouldn't you acknowledge that the issues relating to our advocacy has been a bipartisan effort in West Virginia?

Mr. VAN NOSTRAND. Well, certainly we have a split in parties and control in West Virginia. I think the point I was making about Kentucky was the bipartisan effort to start the conversations, to have the issue. You look at the shaping our Appalachian region process—it's going to be another conference in a couple months from now—and you've got this—a Democratic Governor and Republican Congressman who are starting those conversations in Kentucky and talking about the future.

I think it's been effective. I think they're much further down the road of a future. And they don't have the benefit of Marcellus shale. They don't have the benefit of a great energy resource. We should be a better energy State than Kentucky.

So, yes, I understand—I acknowledge that we have a Democratic Governor and legislative control by the House. But we have—I was talking about the Federal and State level. Just the fact that you can have two U.S. Senators battling for that position, Mitch McConnell and Alison Grimes. But the—while that's going on—in a Senate race, you've got this action going on between a Democratic Governor and Republican Congressman to start those conversations.

That's my point. We really need to start those conversations in West Virginia.

Representative JENKINS. Are you thinking those conversations are not already being had about the future of West Virginia?

As a former member of the legislature, we talked about Marcellus shale. West Virginia was a leader in establishing legislative policies relating to how we're going to, in an appropriate way, seize that energy opportunity. We are talking about the south and issues relating to the future of Southern West Virginia. So when you say I think West Virginia should start—I think you're not giving credit for the kinds of efforts and discussions that are already being had.

Let me ask you—you also pointed a finger at West Virginia relating to the suit against the EPA. You and I are both attorneys by education. Never ask a question you don't know the answer to. Is Kentucky one of the States that is suing the EPA?

Mr. VAN NOSTRAND. Yes, they are.

Representative JENKINS. I thought they were.

Mr. VAN NOSTRAND. I don't deny that's going on at one level. The question is, while you have these positions being taken at one level, is there hard work going on behind the scenes to figure out how we're going to make this work for our State?

That's happening.

Representative JENKINS. Chairman Rogers, the chair of the committee I serve on, appropriations, is passionate, passionate, and you give him credit for SOAR. I too give him credit. But he is as articulate and as passionate and as bulldogish as they come in fighting the EPA in standing up for coal.

You can walk and chew gum at the same time. You can talk about the future, but you can also be a passionate advocate for coal.

So I'm having a difficult time when you compare Kentucky and West Virginia. Kentucky is suing the EPA. Kentucky is representative and Congress is fighting the EPA. Kentucky and West Virginia in a bipartisan effort are standing up for coal.

So while you can point to a program or project, I think you can—a fair analysis, you can find that West Virginia too is looking to the future.

Mr. VAN NOSTRAND. I guess I would still go back to Governor Beshear a few years ago talking about an all-of-the-above energy strategy which really looked at, not just coal, but also taking advantage of that State's renewable resources—that State's energy efficiency resources, that kind of leadership going on. And we have not had—I mean, the steps our legislature is taking in the last couple of years—the last year, we're moving in an entirely different direction.

Representative JENKINS. In a bipartisan effort?

Mr. VAN NOSTRAND. Not this year. We have a Democratic——

Representative JENKINS. Do you know what the vote in the House and Senate——

Mr. VAN NOSTRAND. I testified on the——

Representative JENKINS. Was that not bipartisan?

Mr. VAN NOSTRAND. Yes, it was.

Representative JENKINS. Did the Governor sign the repeal of the Renewable Portfolio Standard?

Mr. VAN NOSTRAND. Yes, he did.

Representative JENKINS. Is he a Democrat?

Mr. VAN NOSTRAND. Yes, he did. He also signed the bill to wind down that metering.

Representative JENKINS. Thank you.

Senator CAPITO. Mr. Trisko, quickly, on the MATS Rule that is the rule that was put into effect in 2008—is that——

Mr. TRISKO. 2011, Senator.

Senator CAPITO. 2011. Excuse me.

How has the implementation of the MATS Rule impacted the UMW?

And do you expect similar impacts from this Clean Power Plan to affect the United Miner Workers and their work force?

Mr. TRISKO. Thank you, Senator.

When the MATS Rule was initially proposed, the UMWA estimated potential plant closures amounting to 56,000 megawatts of capacity. Largely, the smaller and older generating plants, such as Kanawha River, Sporn, they would not be able to afford the capital expenditures for the investment and compliance with MATS. At the time, EPA indicated that their estimate of retirements due to the MATS Rule was 4.7 gigawatts. So we were pretty much in order a magnitude apart in our estimates.

A number of years went by. Other studies were done by Wall Street, by other consulting firms. And the consensus estimate of closures as a result of the MATS Rule—and this will continue through about the year 2017. There are 1- and 2-year extensions available under that rule—are on the order of 50 gigawatts of capacity.

You will have another 20 or so gigawatts that will retire for any reason—a number of reasons; lower natural gas prices, reduced industrial demands, so on and so forth. Those two numbers, 50 gigawatts for MATS and another 20 make up the 70-plus gigawatts that EPA indicates will retire apart from the Clean Power Plan.

Now, Senator, if I might, there's been a missing element within this discussion as it relates to reliability and the impact on coal. We are not appropriately considering at this point the potential impacts of EPA's revision of the 8-hour ozone standard. The comment period on that rule closed last week. EPA has proposed a range of 65 to 70 ppb. The current stand is 75 ppb. They're also put forward an alternative standard of 60 ppb.

EPA's regulatory impact analysis indicates that at the 65 ppb proposed standard, 51 gigawatts of coal capacity—which are identified in the docket in this rulemaking—are subject in EPA's view to potential retrofit of selective catalytic reduction technology, SCR. It's like the catalytic converter on your car, except it's the size of a house and it costs a couple hundred million dollars.

EPA likewise has identified that many of these units subject to SCR requirements are older and smaller units. We believe it more likely that those plants would retire rather than invest in SCR capacity. So, in effect, we are looking at yet another 50 gigawatts or 50,000 megawatts of potential capacity shutdowns between now and roughly the year of 2023. So that would bring the total—taking it from 122 gigawatt reduction from EPA's regulatory impact analysis, it would take it above 150, in the direction of 170 gigawatts. Our total coal fleet is just over 300 gigawatts.

Frankly, Senator, I do not know how this Country keeps the light on with the loss of 150 or more gigawatts of coal capacity. That represents more than 20 percent of our total electric generation when you consider the generating capacity of those facilities.

Senator CAPITO. Thank you. I wanted to talk a little bit about the letter that Senator McConnell wrote. I think, Professor, you might have talked about it. My reading of the letter basically says every State has to have a State implementation plan. I asked Administrator McCabe if the States do not have a State implementation plan, what happens. And she said the EPA will make the implementation plan. Which sent sort of the wrong kind of chills down my spine.

But in any event, I think McConnell's point is, if you're going to impose certain standards on every State and the State has to come up with the State implementation plan, the State makes the difficult decision—the State says we're going to close this many power plants, your work force is going to be cut, you know, and the difficult, hard—at the community level, employment level, price and cost of electricity level are made at the State.

I think what McConnell is saying is if the EPA wants to go in this direction and they're federally allowed to do it, then they're the ones that are going to have to be the ones that make the tough decisions. The EPA is going to be the ones that's going to tell West Virginia how we're going to meet a standard that we basically don't think we're going to meet.

Which leads me to a whole other issue, which is the regional issue. You mentioned it, I think, in your statement. The plan allows for you to be able to go to different regions so that you could maybe capture certain statistically reductions from your regions. We've been discussing our region. We're 95 percent reliable on coal. We export our coal. We export our electricity. Who is going to want us in their region?

I mean, our numbers are not going to improve anybody's numbers. So we're going to be in an island here. I'll quote Mr. Richardson when he says, It must be recognized that job impacts will be unevenly disbursed. Some regions and States will be winners—I appreciate your frankness here—and others will experience economic consequences with a shift away from coal.

I understand basically there's winners and there's losers. And we are in a really difficult position here in our State.

So I think that's why McConnell—and if you would like to respond to the McConnell letter, Professor, I want to give you that opportunity since I brought it up and that was part of your statement.

Mr. VAN NOSTRAND. I understand the position the Senator is taking. My point is, I think—those are tough decisions. But I think the States know better. I think our goal—we had our conference back in February a year ago. Our goal is—what flexibility is EPA going to provide us?

Because our goal is to try to figure out how to comply with this rule in the manner that has the least disruption on the economy. What is our lowest cost compliance path?

And I think the States know that better than EPA. So I think the States ought to try to work with the EPA, first, to shape this rule.

In response to what Mr. Trisko said, this is a proposed rule. The final rule is going to come out in December. It could look entirely different in terms of—and there's nothing that's required by these building blocks. The building blocks were used to come to the best emission reduction number, the 20 percent number for West Virginia. There's no requirement. The building blocks were a tool used by EPA.

The final rule is going to come out this summer. I think the States—because we're in a better position to know what's going to work, we ought to be taking advantage and try to work with EPA and—because a Federal plan is going—they don't know the State as well. Chances are the compliance costs are going to be higher, so our utility rates are going to be higher than they need to be.

Mr. RICHARDSON. If I could just add. One of the things I was trying to emphasize with my testimony was that it is absolutely critical that we work to diversify our economy here. It just doesn't make sense to have all of our eggs in one basket.

I can tell you as well as anybody in this room how proud I am of my heritage, my family's heritage mining coal. OK. But it just doesn't make sense to have our entire economy based on one thing that is subject to these boom-and-bust cycles.

Think of it in terms of a risk framework, right?

So you don't want to risk things moving forward and changing that you don't have control over, whether it's who is sitting in the White House or whether it's how much coal China decides to burn. They're working on burning less coal over the next decade.

So there's a lot of issues here that we don't have control over in Southern West Virginia. So what I'm trying to say is, why can't we build the solar panels? Why can't we build the components of the wind turbines going up?

We can do that here in West Virginia. But we have to decide we're going to invest in that and in those different sectors of the economy.

Senator CAPITO. I appreciate that.

Let's go to CCS really quickly, carbon capture and sequestration. The EPA uses that as sort of a—what do I want to say—blunting of the effect of the regulations. Well, if we move forward on CCS—and I certainly have been a broad—and will continue to be a big supporter of the research and development of the CCS. Because I think for all the reasons we've talked about, coal still is going to have a role. Maybe we're disputing the largeness of the role. We think it still needs to have that good baseline, solid role that represents the fuel that it is.

The EPA uses the Kemper plant in Mississippi—and you mentioned that in your statements—as the gold standard for CCS. Well, I just saw the president of—I think it's Southern Company owns that plant, over $2 billion cost overrun. They still don't have their sequestration protocol in effect. There are some—I think some great research is going on in terms of enhanced oil recovery and other things to use once you capture the carbon.

But I know that since I had the Mountaineer plant in Mason County for many years, when I represented Mason County, they were doing a project on that plant on CCS with—I think it was Olstrum and the Department of Energy. They had to pull the plug on it. Give us the top two reasons why, please, Mr. Patton.

Mr. PATTON. Well, it was simply a pilot project. And when we looked at scaling it up, the cost of it was just prohibitive at that time. As you pointed out, the Kemper station in Mississippi is somewhere north of $7,000 a kw. So if you were building a thousand megawatt plant, it would be $7 billion—over $7 billion plant. And a new combined cycle gas unit, as I said earlier, is $1.3 billion. So the technology——

Senator CAPITO. It's just not economically feasible?

Mr. PATTON. It's not economically feasible.

Senator CAPITO. Not to say it never will be?

Mr. PATTON. Right. And we should continue to invest in technology to ensure a long and bright future for coal.

But one thing important to note here is that—we keep talking about—you go from coal to renewables to solar to energy efficiency. And all of those things are great. I believe that they should be a significant part of a utility portfolio. And Appalachian Power Company and AEP is moving—as I pointed out in my testimony, if you look at our overall coal consumption, it has dropped. But there's a cost—not only to those technologies, which are more expensive. There's also a cost of abandoning operational facilities that serve customers.

So to willy-nilly just say we're going to stop using these coal plants and we're going to go and invest in a bunch of windmills and solar panels and have our customers pay for the coal plants that we abandon, and to pay for the solar and the windmills is just not—it's crazy. It's not what you're going to do.

The other thing is that renewables—again, they're an important part of the portfolio. But the wind doesn't blow all the time, and the sun doesn't shine all the time. And the bottom line is, you need some type of fossil based or nuclear power to support solar and wind. You have to have those as backups.

As we saw during the polar vortex, the wind didn't quite blow the way it was forecasted to. When I was president of the Texas company, there were a couple of times we came very close to outages in similar situations. So it's just important to keep that in mind. It's not a binary decision.

Senator CAPITO. Thank you.

Congressman.

Representative JENKINS. Mr. Patton, let's stick with you. Let's try just for a second to—where the rubber meets the road. You've alluded to it in the last moment of your comments; price and availability.

No. 1, once you convert a power plant away from coal, do you ever convert it back?

Mr. PATTON. You could under the right economic conditions. But you would not today convert it back. Because all you do with a plant that you convert is you convert the burners to gas-based burners as opposed to burning coal.

Representative JENKINS. In your decisionmaking process, you've listed out several coal-fired power plants that are being taken offline, being mothballed. There are plants that are being converted. Is a significant—not total. Is a significant contributing factor to those business decisions that you were making the policies, the proposals, the actions from a regulatory standpoint from this administration and this EPA?

Mr. PATTON. Absolutely. The Kanawha River plant runs fine. It's just—it doesn't meet the EPA requirements.

Representative JENKINS. Does it meet the EPA requirements as of today?

Or meet the EPA requirements under a set of proposed rules, I know in multiple areas, looking forward?

Mr. PATTON. No. The Kanawha River plant falls in the group of plants that Mr. Trisko pointed out. It's one of those older smaller plants, which putting a scrubber on that unit does not make economic sense. It does not meet existing MATS requirements.

Representative JENKINS. So this is death by a thousand cuts. We already have rules and regulations that have been put in place in recent years that are causing power plants that are already operational, working fine, just don't meet—and you are forced as a result to take those offline?

Mr. PATTON. That is correct.

Representative JENKINS. With regard to the issue—and you referenced it in your comments earlier. I am very concerned, just as the Senator is, about the cost of energy on fixed income—predominantly seniors as a percentage of their household budget. You referenced over the last few years as a result of the new expenditures you've been required to make or the changes. Share with me, again, those numbers in terms of what it—what the price impact for a person's electric bill.

Mr. PATTON. With the $2.2 billion investment that we made at John Amos and Mountaineer plant—we spent approximately $2.2 billion to comply with the MATS and also with the Cross-State Air Pollution Rules.

Representative JENKINS. Let me make sure that I understand. So you have regulations that require you to make investments, 2.2 billion. You are a regulated utility. You can't charge one penny more than what the Public Service Commission in West Virginia says you can pay. So when you make that $2.2 billion investment, do you then go to the PSC and say would you all—here is a rate increase to cover these costs, and the PSC then says, yes, you're going to be granted authority to raise your rates?

Mr. PATTON. Yes.

Representative JENKINS. Are the people paying for that $2.2 billion of investment that you've already made in their utility bills?

Mr. PATTON. Yes, they do.

Representative JENKINS. And those are for the regulations already. Have you estimated to any extent possible if the proposed rules would be implemented—and we've got testimony here that says they don't think the proposed rules go far enough.

If these proposed rules as is get implemented, do you have a cost estimate that one of my constituents from Southern West Virginia would have to pay on an average utility bill?

Mr. PATTON. The numbers are broad throughout the Nation. Here in West Virginia, we would be looking at—just solely based on the—on the proposed rules, we would be looking at an additional 25 percent. That's not—that does not include things like the investment in transmission that's going on right now.

Representative JENKINS. When you say—are you saying that 25 percent may be the floor that it could be in—that the actual number when other factors are considered, the percentage increase might be more than that?

I wasn't sure if I understood your last comment there.

Mr. PATTON. No. I can't—in fact, I believe I misspoke. I had to think about the number. In fact, it's not 25 percent. It's actually—I think the forecast for West Virginia is actually 15 percent, is what it is for West Virginia.

Whether or not that is precise or it could be more, I don't know. I can just base it on the calculations based on the current proposal.

Representative JENKINS. Finally—I heard it from Gina McCarthy. I hear it every time the issues of these rules get discussed. These are proposed rules. These are proposed rules. It's almost kind of a remain calm, don't worry about it. We're going to have to wait to see what the final—I can't imagine an administrative approach that is so calculating that would say, let's do something really strong, get everybody worked up in a proposed, and then we'll come in and back off and everybody will say, look, we dodged a more aggressive bullet. I can't imagine—shame on this administration if that was their approach. The fact from a—in your world, do proposed rules matter?

Mr. PATTON. Absolutely. Because they drive costs.

Representative JENKINS. You're making decisions, are you not, literally every day, week and month about the future?

You don't plan a week out. Don't you plan years out?

Mr. PATTON. Absolutely. Power plants typically have a life of 30 years. Therefore, you're making 30-year decisions. When you've made major capital investments, like scrubbers, you're typically looking at an additional 20 years associated with those types of investments.

Representative JENKINS. So are you making decisions as a company with an eye toward what is being proposed in this rule?

Mr. PATTON. Oh, absolutely.

Representative JENKINS. Looking ahead?

Mr. PATTON. Absolutely.

Representative JENKINS. Proposed rules have consequences?

Mr. PATTON. They have consequences. In that I would suggest to you that much of the industry is hamstrung on really what it's going to do with some of its generation right now because there's so much uncertainty around what these rules will ultimately be.

Representative JENKINS. Senator, if I could ask maybe one more to Mr. Trisko. Thank you for your leadership and your effort.

The comment was made earlier by Mr. Richardson, special considerations for families is needed. Let me—I didn't delve into kind of what he meant by that. I think we kind of—probably can believe what he's suggesting.

From your perspective, from a representative of the UMWA, what sort of, quote, special considerations, do you think are necessary to help the hard-working coal miners of West Virginia get through this storm that they're faced with?

Mr. TRISKO. Congressman, that's a wonderful question. The answer is that we need policies that encourage the continued utilization of our Nation's greatest fossil resource. You know that the coal reserves in the United States have greater energy content than all of the oil in Saudi Arabia. We do not have policies that enable us to continue to utilize that. Rather than an all-of-the-above energy strategy, we appear to be headed toward a natural-gas-only strategy. That is an all eggs in one basket gamble.

When we see the play out of the reduction of capital expenditures in drilling that is ongoing within the oil and gas sector, when we see the development of LNG export terminals, watch out for the price of natural gas and what your consumers will pay.

As for workers, unfortunately, because our members tend to be among the highest wage and highest benefit of workers in the rural areas of Appalachia, the loss of one of our jobs is equivalent to the loss of more than three jobs elsewhere in the economy. Those jobs are not made up in alternative sectors because the alternative sectors do not exist.

When you look at the impact in, for example, a school district of the closure of a power plant which is a major contributor to the tax base of the region, and the closure of the associated coal mines, you find a cliff. And the cliff is where the school district once had funds available to support its students. Those funds through its tax base are reduced by half or more.

I was out in Colorado a few months ago talking to 500 folks in a high school gymnasium where they were addressing the prospect of a loss of a nearby power plant and coal mine. The president of the community college, a gentleman in his 70s, came up. He was one of the last to speak. He said ladies and gentlemen, let me tell you what it means to this community if we lose the Craig Power Plant and the Twenty Mile Coal Mine. I run these numbers every day. I live with these numbers. If we don't have that power plant—in fact, if we lose just one unit at that power plant, I cannot guarantee you that our community college will be able to remain in business and provide one half of the course offerings and faculty that we now have.

This gentleman recognized clearly that the loss of those contributions to the local tax base, to the community college would not be replaced in rural Colorado. And nor will they be replaced in Southern West Virginia.

Frankly, it's simply happy talk to suggest that there are solutions at the State or the Federal level. We've been at this since the great society and the Johnson administration and the Appalachian Regional Commission. The funds are not there in sufficient quantity to make up for the kinds of losses that we in the UMWA, the IBEW, the boilermakers and others are beginning to experience. I apologize for the length of the question, but my blood pressure increased.

Representative JENKINS. I like it when I touch a nerve.

Let me see if I can touch one more nerve. The Administration and their budget is throwing out a big figure, a billion dollars, to invest in impacted communities, West Virginia and other parts of the Country because of this agenda.

I'm still confused a little bit because my curiosity is—this is—where are they taking this money from to make that?

On the one hand, I hear maybe that money is contemplated as a result of a tax on coal. Isn't that incredible? We're going to tax coal more and turn right around and say, isn't this great, we're going to give money back to communities, but we're going to try to kill coal through higher taxes in the first place. Or they want to take it from the abandoned mine fund.

Do you know under the President's proposed investment where he is suggesting that money come from?

And do you have an opinion as to whether this is a good investment considering the source of the funding from which it is being taken?

Mr. TRISKO. Congressman, I'm not an expert on the Administration's budget. There have been proposals to increase severance taxes on western coal and transfer those increased severance taxes east as a compensation mechanism. I suggest that you confer with your colleagues west of the Mississippi River as to their views on that proposal.

But a billion dollars, put that in the context of the numbers cited in my testimony, the contribution of West Virginia coal, just the West Virginia economy, to your gross State output, it's about $15 billion a year. And we're talking about a billion dollars applied to coal generally. It's a drop in the bucket.

Representative JENKINS. It's a billion dollars nationally.

Mr. TRISKO. It's really a drop in the bucket. Congressman, our investment in research and development technology that would allow us to successfully deploy carbon capture and storage technologies is a far better place for those investments. It's got to be a lot more than a billion dollars.

A few years ago, we were looking at $150 billion in potential funds available for commercial CCS applications. Now, that did not come to pass for one reason or another. There are a number of bills in the Senate and in the House seeking to increase funds available for CCS.

If you want to develop technology that will enable coal to be burned cleanly in a carbon-constrained world, CCS or CCUS is the way to go. But we must get to the lower cost second and third generation technologies. The first generation technologies that AEP applied at the Mountaineer plant proved themselves to be unduly expensive. And that's why they couldn't proceed to commercial deployment.

We have to have sufficient resources available initially at the U.S. Department of Energy. And I'm talking far more than what was provided in AARA in order to enable those second and third generation technologies to be deployed.

When we have those technologies, then coal will be able to compete effectively against natural gas on a CO_2 basis. That's the direction that we need to be headed.

Mr. RICHARDSON. If I could just add a clarification. The proposal that you were just mentioning was not an administration proposal. That was a Center for American Progress proposal in a report that they just released a few minutes ago that talked about fairness among Federal coal mine leasing royalties. So that was not an administration thing.

The thing that you're thinking of, the billion dollars was, in fact, from a proposal to shift some of the money from—its existing money from the abandoned mine lands fund that has not been appropriated and actually spend it on communities here. It was a billion dollars over 5 years. It would require Congress to actually change how—the formula for how those funds are related.

I'd like to add one other thing, which is that—it's going to be difficult to say this. But the truth of the matter is that a lot of the coal that—the resources that we have here in West Virginia, here in Wyoming, around the world, have to remain in the ground. OK?

If you—there are recent studies out there that suggest that 92 percent of our current coal reserves must remain in the ground to give us any hope of avoiding the worst consequences of climate change.

And what I'm here to tell you today is that is a clear and present danger. Not only to this Country, but to countries around the world. We're going to figure out a way to solve it one way or another. My deepest fear is that we're not going to solve this problem here in Southern West Virginia at the same time.

I'm not making any—I'm not trying to be Pollyanna about it, that this is going to be easy or whatever. It's going to be very difficult. But we've got to figure it out.

Senator CAPITO. I think, Dr. Richardson, in your statement you were very honest about that. I mean, I appreciate that. As you said, you have family from West Virginia, good roots in West Virginia.

But I'm glad that Mr. Trisko talked about some of the other impacts. We've talked about job impacts and impacts on the cost of your electric bills monthly. But there is another impact. I know we have at least one county commissioner—we did earlier—in the room.

There is an impact to every single county budget. It's schools, yes. It's roads. It's a whole lot of other things. I can imagine, Mr. Farmer, when you pay your local taxes and as your productivity goes down, it's not just the coal mine, it's all the other businesses in and around. So it has a much greater effect to the whole community rather than those directly working in that business.

Do you have any further questions?

Representative JENKINS. I don't. Thank you.

Senator CAPITO. I'm going to give the professor here one shot at telling me why you think that the direction that the EPA has gone—we heard Mr. Trisko's opinion on the legality, the legal authority. And you did mention in your statement that the preferable way is to legislate as opposed to regulate, which is what we're seeing, or executive opinions.

Briefly, do you believe that EPA has the legal authority to go as far as they've gone with the four building blocks to bring forth the Clean Power Plan?

Mr. VAN NOSTRAND. Yes, I do. I share some of the concerns of Mr. Trisko in terms of whether or not this particular proposal is necessarily lawful because of the language in 111(d) which refers to sources. I think you would need to go to actual limits on sources from power plants, and you would use the building blocks to determine how much can we reduce the level of emissions on a mass basis. And you would use the building blocks to figure out what that level is.

That's why I do think there is going to be some changes when the final rule comes out. Because I think EPA made a lot of comment on the precise issues that Mr. Trisko mentioned going beyond—outside the fence. I think you can still get there by looking at the language in 111(d), and the sources, use the building blocks to figure out what kind of limits you're going to put on the power plants under 111(d).

As you mentioned, the 111(b)—my comments also raised some concerns, and the Kemper plant is one of them. And I followed Senator Manchin's proposed legislation over the last couple of years as to whether or not the EPA can really preclude one of our energy sources through a rule that way and requiring CCS technology when it's really cost prohibitive and not really commercially available. I think that's—it's clearly causing disproportionate impacts.

So it brings me back to the legislative solution which would have addressed the impacts around the country, the winners and the losers. I think the legislative solution is much better at doing that. I think the EPA to some extent has done that with the best system emissions reduction.

Because we have a 20 percent reduction in West Virginia versus 30 percent under the rule. But there's limitations on how much relief they can provide to a region that's clearly going to be hit much harder than others.

Senator CAPITO. I'm on the legislation with Senator Manchin. And by the way, he was extended an invitation to attend today. I know some folks from his office were here. He was unable to be here. So I want to make sure you all know that he's as concerned about being here today as we would like to have had him.

I would say—in conclusion, I want to thank you all—we will keep the record open in case we have additional questions that we may submit to you in writing. I think we've had a really good discussion in a place where we should be having it, in Raleigh County, Southern West Virginia.

All the impacts that Mr. Farmer, I think, talked about very—from his heart, very locally. The bigger impacts as you look at it more regionally, and then some of the global questions too.

I would like to take the opportunity to say that we are the representatives. You know, this is going to say hokey corny, but we are the representatives of West Virginians. We are West Virginia's voice. And by hearing what you've said to us today—if you disagree with the direction that we might be going, we have that prerogative as your voice to say the direction that we think you want us to go.

So that is—in Washington, we've had a lot of gridlock. We've had a lot of pushes and pulls. We've got to get the train back on the track. I think we're trying. We're doing better. I'm more of a veteran than Evan is in terms of legislative service in Washington. I do think we are trying to work in more bipartisan ways on certain areas where we have common ground.

My pledge to you is to continue to do that. At the same time, I'm going to be the strong and powerful voice that I wish to be in the U.S. Senate to reflect Mr. Farmer and his business, and all of our West Virginia constituents that we see every day. And that we care about your relatives, Dr. Richardson. You know it's a great place.

So we'll end on this note. Beat the heck out of Kentucky on Thursday. We can all agree on that. Thank you very much.

[Additional material submitted for the record follows:]

[Union of Concerned Scientists

POLICY BRIEF

Strengthening the EPA's Clean Power Plan

Increasing renewable energy use will achieve greater emissions reductions

THE CARBON-CUTTING POWER OF RENEWABLE ENERGY

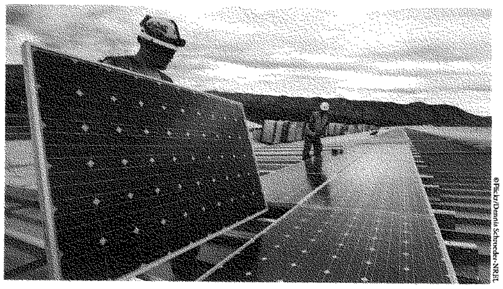
Investing in renewable energy is a smart and cost-effective solution for delivering the sharp reductions in power plant carbon dioxide (CO_2) *emissions needed to help slow the pace of climate change. The U.S. Environmental Protection Agency's (EPA's) new Clean Power Plan is an important step toward limiting these emissions from existing power plants. Yet, while the plan allows states to use renewable energy to meet their emissions reduction targets, it significantly underestimates the role of renewable energy in setting these targets.*

The Union of Concerned Scientists has identified a better way to make the most of renewable energy in the Clean Power Plan. Using our recommended modifications, the EPA could nearly double the amount of cost-effective renewable energy in their state targets—from 12 percent of total 2030 U.S. electric sales to 23 percent. If states met these stronger targets, total CO_2 *emissions reductions achieved by the Clean Power Plan would increase from 30 percent below 2005 levels by 2030 to approximately 40 percent.*

In June 2014, the U.S. Environmental Protection Agency (EPA) proposed in its Clean Power Plan the first-ever limits on carbon dioxide (CO_2) produced by existing power plants. These plants are responsible for nearly 40 percent of total U.S. CO_2 emissions, constituting the nation's largest source of this heat-trapping gas. Given that Americans face worsening risks of climate impacts, as clearly reported in the National Climate Assessment, the Clean Power Plan is an important step forward in the effort to limit those risks (Melillo, Richmond, and Yohe 2014). The plan sets emissions rate reduction targets for the power sector state by state, and it would reduce national electricity sector emissions by an estimated 30 percent below 2005 levels by 2030 (EPA 2014a). However, analysis of the rule by the Union of Concerned Scientists (UCS) shows that the Clean Power Plan could deliver much deeper reductions in emissions, especially by taking greater advantage of cost-effective renewable energy options.

This brief outlines a better way to make the most of renewable energy in the Clean Power Plan, and to strengthen its state renewable energy targets as the cost of sources such as wind and solar power decline. The UCS proposal builds on the EPA's approach while utilizing the latest available market data, demonstrated rates of growth in renewable energy, and existing state commitments to deploy renewables. Using our recommended modifications, the EPA could *nearly double* the amount of cost-effective renewable energy in their state targets—from 12 percent of total 2030 U.S. electric sales to 23 percent (Figure 1, p. 3).

The EPA should adopt a similar approach, and thereby increase the total emissions reductions achieved by the Clean Power Plan from 30 percent below 2005 levels by 2030 to approximately 40 percent. Strengthening other parts of the plan could help achieve even deeper reductions.


©Flickr/Dennis Schroeder-NREL

Investing in solar power and other renewable energy technologies is a smart and cost-effective solution for cutting CO_2 *emissions.*

The Basics of the Clean Power Plan

The EPA draft Clean Power Plan establishes state-by-state emissions rate reduction targets, and it offers a flexible framework under which states may meet those targets. The rule provides for a number of options to cut carbon—called "building blocks"—and determines state emissions rate targets by estimating the extent to which states can take advantage of each of them. Renewable energy resources account for one of the building blocks, alongside efficiency improvements at individual fossil fuel plants, nuclear power, shifting generation from coal to natural gas, and greater energy efficiency in buildings and industries. The EPA determined these building blocks to be the best system of emission reduction (BSER) for existing power plants—a technological and economic regulatory determination required by the Clean Air Act (CAA).

Each state's target derives from the aggregate level of emissions rate reductions coming from the suite of building blocks. Thus assumptions made by the EPA about the emissions reduction potential of each building block in a state directly affect its overall target. If the EPA's assessment for any of the individual building blocks is too modest, so too will be the state's final target.

Targets differ across states because of each state's unique mix of electricity-generation resources—and also because of technological feasibilities, costs, and emissions reduction potentials of each building block, all of which vary across the country. Because states are free to combine any of these building blocks in a flexible manner, they could therefore opt to meet a much larger share of their overall target through expanding their use of renewable energy resources.

Coal-fired power plants are the electric sector's largest source of heat-trapping CO_2 emissions. By strengthening state renewable energy targets under its Clean Power Plan, the EPA could increase the total power sector emissions reductions achieved from 30 percent below 2005 levels by 2030 to approximately 40 percent.

©Flickr/WalterPro4755

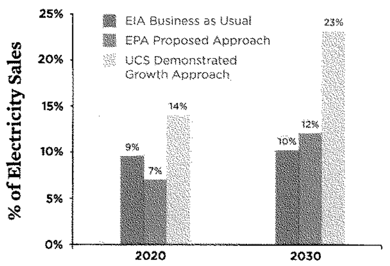
The EPA's decision to include renewable energy as an eligible compliance option for states is sensible, as technologies such as wind and solar—which already deliver safe, reliable, and affordable power to millions of U.S. consumers—emit no carbon in their operation and are a viable alternative to fossil fuels. All states have significant and diverse renewable energy resource potential that can be developed. And as a result of falling costs, advances in technology, and strong state policies, renewable energy technologies are in a strong position to compete with the other emissions reduction strategies allowed under the Clean Power Plan.

The EPA Underestimates the Power of Renewable Energy

While the EPA draft rule specifically allows states to use renewable energy as an affordable way to meet their emissions reduction targets, it significantly *underestimates*, in several ways, the potential role of renewable energy in setting state targets. The Clean Power Plan does not adequately capture renewable energy deployment rates that states are already achieving. The plan also fails to reflect the continued growth and falling costs of renewable energy projected by market experts. Indeed, the EPA's proposal falls short of the national renewable energy generation levels that the U.S. Energy Information Administration (EIA) projects would occur in 2020 under a business-as-usual approach; the proposal's 2030 results are only marginally higher than the EIA's projections (EPA 2014a; EIA 2013) (Figure 1).

In the draft Clean Power Plan, the EPA presents both a proposed approach and an alternative option for determining the emissions reduction potential of the renewable energy building block. The proposed approach splits the nation into six regions and establishes conservative regional targets for renewable energy by averaging the 2020 targets of existing state-level renewable electricity standards (RESs) within each region. RESs, which have been adopted by 29 states and the District of Columbia, set a proportion of renewable electricity that utilities are required to supply over time. The EPA then calculates the annual growth rate needed to achieve the regional target in 2029, using state renewable energy generation levels in 2012 as the baseline. However, under the plan, the ramp-up in renewable energy does not begin until

FIGURE 1. The EPA's Renewable Energy Targets under Its Proposed Clean Power Plan Are Modest



The EPA's proposed Clean Power Plan requires states to limit CO_2 emissions from power plants through power plant efficiency improvements, fuel switching, renewable energy, and energy efficiency. But the agency's proposed renewable energy targets significantly underestimate the potential of these resources, and result in barely any additional renewable energy beyond what would have occurred under business as usual (i.e., without the proposed rule). By contrast, if the EPA adopted a modified proposal for setting state targets—the UCS Demonstrated Growth Approach—grounded in states' actual experience in deploying renewable energy, the renewable energy targets within the plan would nearly double at the national level.

SOURCES: EIA 2013; EPA 2014A.

2017, despite significant U.S. renewable energy capacity that has already been installed or is under development. States with renewable energy generation below the regional target make annual progress at the predetermined growth rate. Once a state reaches the regional target, the plan assumes renewable energy generation remains flat through 2030.

The EPA's proposed approach for setting state renewable energy targets does not represent the CAA-required "best" system but more of an "average" system, and the approach results in the following anomalies:

- In seven states, actual renewable energy generation levels in 2013 exceed the EPA's renewable energy targets in 2030.
- Seventeen of the 29 states with RES policies have lower targets under the EPA approach than what is already required under their respective state laws.
- The average annual national renewable energy growth rate under the EPA proposal is 0.65 percent of total sales between 2017 and 2030. By contrast, many states have already been achieving an average annual growth rate of more than 1 percent over the last five years.
- Although the EPA's methodology aims to have states ramp up their renewable energy level toward reaching their respective regional targets, as many as 25 states do not actually reach this goal by 2030 because of the low annual growth rates assumed under the agency's proposed approach.

In its alternative approach to determine the BSER for the renewables building block, the EPA sets state targets based on the lesser of two methods: an assessment of market potential as projected by its own modeling, or a national benchmark rate for renewables deployment informed by data on existing renewable energy generation and resource technical potential (EPA 2014b). However, this alternative approach also underestimates the potential for renewable energy to cut carbon emissions. Nationally, it results in virtually the same renewable energy target as the EPA's proposed approach, though the distribution of renewable energy differs at the state and regional level.

States have the technological and economic potential to raise their renewable energy use to much higher levels than what the EPA is proposing in the Clean Power Plan. By specifying a larger role for renewable energy in setting state targets, the EPA could ensure that the Clean Power Plan achieves greater overall carbon emissions reductions.

Proposing a Stronger Role for Renewable Energy

UCS has developed a modified proposal for determining the BSER for the EPA's renewable energy building block. The Demonstrated Growth Approach for setting state renewable energy targets would improve on the EPA's approach by incorporating the following core components:

- Setting a national renewable energy growth rate benchmark based on demonstrated growth in the states from 2009 to 2013
- Assuming full compliance with current state RES policies, as set by law, that require certain percentages of electricity to come from renewable sources
- Accounting for actual and expected renewable energy growth between 2013 and 2017

Like the EPA, our state-level renewable energy targets begin in 2017—though compliance isn't required until 2020—and ramp up through 2030. To determine each state's 2017 baseline generation levels, we use actual generation data from 2013 (the EPA's approach uses 2012 data) and add projected generation from wind and utility-scale solar projects known to be under construction through 2016.

To calculate state renewable energy targets through 2030, we employ a four-step approach:

1. First, we use EIA data to calculate each state's average renewable energy growth rate over the five-year period from 2009 to 2013. We find that, on average, states increased their renewable share of electricity sales by 1 percent annually (EIA 2014). This growth rate serves as our national benchmark. The 2009–2013 benchmark period accounts for the recent rapid growth in wind and solar technologies; it eases fluctuations in development due to uncertainty around federal tax credit expirations and extensions and captures much of the historic development spurred by state RES policies—a key driver of renewables growth. Eleven of the 15 leading states that have achieved growth rates at or above the national benchmark from 2009 to 2013 have also achieved a 1 percent or higher average annual growth rate over a 10-year period from 2004 to 2013.
2. For states below the 1 percent national benchmark, we assume that they gradually ramp up to that rate from 2017 to 2020. This period therefore serves as an opportunity for states that have not been as active in deploying new renewable energy sources to catch up to the national benchmark. Renewable energy is assumed to grow after 2020 in these states at an annual rate of 1 percent of total sales through 2030.
3. For the 15 leading states among those that have been deploying renewable energy at or above the national benchmark, we increase their respective renewable energy targets from 2017 to 2030 at each state's average annual growth rate during the five-year benchmark period, up to a maximum of 1.5 percent per year. We view this as a reasonable upper limit that can be sustained over time in states with strong renewable energy potential. Moreover, a 1.5 percent growth rate is consistent with renewable energy targets set by leading RES states.
4. Finally, to account for full compliance with mandatory state RES laws, we assume that states achieve the greater of two measures: the generation projected by our growth rate approach; or the level needed to meet states' respective RES targets for each year from 2017 to 2030, as projected by the Department of Energy's Lawrence Berkeley National Laboratory (LBNL 2013). To ensure reasonably achievable renewable energy penetration rates during the compliance period, we also cap the total share of renewable generation for any state at 40 percent of total state electricity sales, a level that several studies by grid operators, utilities, and government agencies have shown can be achieved at the state and regional level in this timeframe while maintaining reliability (GE Energy Consulting 2014; NREL 2012a; NREL 2012b; Synapse Energy Economics 2011; Cleetus, Clemmer, and Friedman 2009). Only seven states hit this cap prior to 2030.

Key constraints included in our proposal, such as the 1.5 percent annual growth rate cap and the 40 percent cap on the overall target, are reflective of current conditions and thus should be flexible over time. As the EPA undertakes regular reviews of the Clean Power Plan, which should occur at least every eight years as allowed by the Clean Air Act, these constraints could be adjusted upward or eliminated to reflect improvements in renewable energy technologies, grid integration techniques, and falling costs.

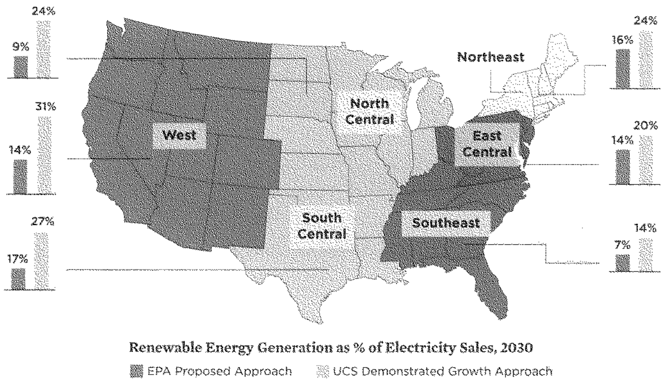
Deploying More Low-cost Renewables through the Clean Power Plan

The UCS proposal leads to stronger renewable energy targets for states than those proposed in the EPA's draft Clean Power Plan. If all states met these targets, the nation's electricity coming from renewable energy in 2020 would double compared with the EPA's proposal—from 7 percent of total U.S. electricity sales to 14 percent. By 2030, it would result in a 23 percent share of renewable energy, as compared with 12 percent under the current EPA proposal. All regions of the country would see higher renewable energy targets under our improved methodology (Figure 2), with higher targets in all but four states (Figure 3, p. 6).

By increasing state renewable energy targets to these levels, UCS analysis shows that total CO_2 reductions achieved by the Clean Power Plan could increase from 30 percent below 2005 levels to nearly 40 percent, assuming that the additional renewable energy generation displaced mostly natural gas. If more coal were displaced, total emissions reductions could increase above these levels. And of course, improvements in other building blocks within the Clean Power Plan, as well as states' decisions to deploy renewable energy beyond their targets, could further increase the total level of emissions reductions.

Some of the largest increases in renewable energy targets occur in the leading renewable energy states of the Upper Midwest and the West. Under the EPA's approach, many of the renewable energy targets in these states reflect little, if any, more renewable energy than what they have already achieved. By contrast, our approach encompasses the reasonable expectation that these states will continue to grow at rates similar to what they are currently demonstrating up to a maximum of 1.5 percent. Further, we assume that full compliance with current state RES policies—a legal requirement, where they exist—should be incorporated into state renewable energy targets. This assumption has the greatest effect among Northeast and Mid-Atlantic states, as well as in California.

FIGURE 2. Regional Comparison of Renewable Energy Targets, 2030



The UCS Demonstrated Growth Approach for setting state targets under the Clean Power Plan's renewable energy building block leads to higher targets for 2030 than does the EPA's proposed approach, and in every region of the country. In the upper Midwest, West, and Southeast regions, the amount of cost-effective renewable energy generation included in the targets at least double.

SOURCE: EPA 2014A.

Higher Renewable Energy Levels in the UCS Proposal Are Affordable

Achieving higher renewable energy targets under the Clean Power Plan—as proposed by the UCS approach—is also affordable. Diversifying the electricity mix with renewable energy would help reduce the economic risks associated with an overreliance on natural gas (Bolinger 2013; Fagan et al. 2013; Mercurio 2013). Reducing the demand for natural gas would also lead to lower and more stable natural gas and electricity prices.

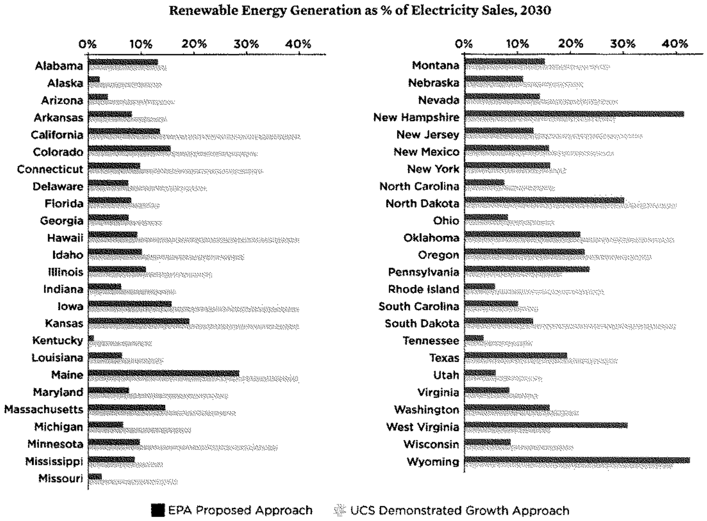
Using the National Renewable Energy Laboratory's Regional Energy Deployment System (ReEDS) model, we analyzed the impacts on electricity and natural gas prices of achieving the state renewable energy targets under the UCS approach compared with business as usual. Our analysis also included updates to technology cost and performance assumptions that reflected data from recent project installations and mid-range projections for future costs (Cleetus et al. 2014).

Under the UCS proposed approach, which leads to 23 percent of electricity sales coming from renewable energy nationally in 2030, national average consumer electricity prices were a maximum of 0.3 percent higher per year than business as usual through 2030, with some regional variation. As a result, a typical household (using 600 kilowatt-hours per month) would see a maximum increase of 18 cents on their monthly electricity bill. Under the UCS proposal, the national average price of natural gas in the electricity sector would be 9 percent lower than business as usual by 2030. Previous studies have shown that reducing natural gas in the electricity sector also can help reduce consumer natural gas prices for heating and manufacturing (Cleetus, Clemmer, and Friedman 2009; EIA 2009; UCS 2009). However, these benefits are not captured in our analysis, which uses an economic model that focuses only on the power sector.

We also found that the incremental cost of increasing renewables under the UCS proposal was within the range that the EPA identifies as meeting BSER cost criteria under the Clean Power Plan (EPA 2014b; EPA 2014c).

Our analysis is a reasonable approximation of the incremental cost impacts of increasing renewables under the Clean Power Plan. We did not analyze the full impacts of implementing the entire draft rule, but focused exclusively on the renewable energy building block. In addition, these results assume unrestricted national trading of renewable

FIGURE 3. Comparison of State Renewable Energy Targets, 2030



This chart compares the EPA's proposed 2030 renewable energy targets for each state with those of the modified approach recommended by UCS. As the chart illustrates, the EPA has underestimated the level of renewable energy that can cost-effectively contribute to state emissions reduction targets. Nationally, the UCS approach nearly doubles the proportion of renewable energy included in the state targets.

SOURCE: EPA 2014A.

energy credits (RECs). RECs represent the energy and environmental attributes of renewable electricity and serve as the basis for documenting ownership rights and trading transactions across the United States in both RES and voluntary markets. RECs and existing REC tracking systems would also be effective in accounting for the contribution of renewable energy within the Clean Power Plan framework (Quarrier and Farnsworth 2014). If there are any policy constraints placed on trading between regions, experience with renewable energy markets suggests that REC prices would likely be higher in some regions and lower in other regions of the country (Heeter et al. 2014). Furthermore, increasing renewable energy, in combination with other technologies and measures to cut carbon emissions—such as greater investments in energy efficiency—would lead to different impacts on energy prices and consumer bills.

The UCS proposal also aims to capture the tremendous growth in renewable energy, driven largely by advances in technology and decreases in costs. Wind capacity increased by 75 percent and solar capacity by 473 percent from 2009 to 2013 (AWEA 2014; SEIA 2014). The national average cost of wind power has dropped more than 60 percent since 2009, making it competitive with new fossil fuel plants in many regions (Wiser and Bolinger 2014). Solar photovoltaic system costs fell by about 40 percent from 2008 to 2012, and by another 15 percent in 2013 (Kann et al. 2014; Barbose et al. 2013). Looking ahead, the two trends of improved technologies and reduced costs are expected to continue (BNEF 2014; IRENA 2014; NREL 2012a).

This growth in renewable energy has helped most utilities comply with their state RES requirements at little or no cost to consumers, and in some cases even providing them with net savings (UCS 2013). A recent federal government study, relying primarily on data from utilities and state regulators, found that between 2010 and 2012 the cost of complying with RESs in 25 states ranged from a net savings of 0.2 percent of retail rates to a net cost of 3.8 percent, with a weighted average cost of 0.9 percent (Heeter et al. 2014).

Recommendations

Achieving higher levels of renewable energy deployment, and greater emissions reductions, will require strong actions over the next decade. Smart policies, such as a strengthened Clean Power Plan, could accelerate the advances in renewable energy use already under way. State renewable electricity standards and carbon caps have already been shown to work, and they could also be effective and affordable ways for states to meet their requirements under the EPA's Clean Power Plan; carbon-pricing policies have also proven successful at the multi-state or regional level in delivering more cost-effective outcomes.

To accelerate the transition to a low-carbon power sector, the UCS recommends that:

- **The EPA should expand the role of renewable energy in establishing state emissions rate reduction targets.** Specifically, the EPA should revise its methodology regarding the renewable energy building block's contribution to state targets, and the agency should set renewables growth rates that better reflect deployment rates already being achieved by many states. The EPA also should use actual generation data from 2013 and include recent and planned renewable energy development between 2013 and 2017. Finally, it should incorporate full compliance with current state RES laws.
- **The EPA should commit to reviewing and strengthening state emissions reduction targets, as well as state renewable energy targets,** by 2025 to ensure that the Clean Power Plan is updated to reflect the latest cost-effective opportunities for cutting CO_2 emissions.
- **States and the EPA should implement measures to prevent double counting of renewable energy generation** in complying with the Clean Power Plan. This can be accomplished by (a) using—and, where necessary, expanding on—existing regional renewable energy credit tracking systems; and (b) ensuring that compliance credit goes to the states where the purchasers of renewable energy generation or credits reside, regardless of where the renewable generation is physically located.
- **States should prepare to develop and implement strong compliance plans** that include policies to increase their reliance on renewable energy resources to meet as much of their emissions reduction targets as possible. Toward that end, states should work with other states to find the lowest-cost carbon reduction options, if advantageous. States should also work with regional grid operators to identify and implement policies and measures to ensure that higher levels of renewable energy can reliably and affordably be added to the grid (UCS 2014).

Sharp reductions in power plant CO_2 emissions are critical to help slow the pace of climate change. The UCS proposal for modifying the renewable energy building block under the EPA's Clean Power Plan provides a powerful framework for expanding the use of such energy and putting us on a path toward a clean, affordable, and low-carbon electricity system.

Rachel Cleetus *is senior climate economist in the UCS Climate and Energy program.* ***Steve Clemmer*** *is director of energy research and analysis in the program.* ***Jeff Deyette*** *is energy campaign analytic lead and assistant director of energy research and analysis in the program.* ***Seth Mullendore*** *is energy analysis associate in the program.* ***Jeremy Richardson*** *is senior energy analyst in the program.*

REFERENCES

American Wind Energy Association (AWEA). 2014. *U.S. wind industry annual market report 2013.* Washington, DC.

Barbose, G., N. Darghouth, S. Weaver, and R. Wiser. 2013. *Tracking the sun VI: An historical summary of the installed price of photovoltaics in the United States from 1998 to 2012,* LBNL-6350E. Berkeley, CA: Lawrence Berkeley National Laboratory. Online at *http://emp.lbl.gov/sites/all/files/lbnl-6350e.pdf,* accessed on September 15, 2014.

Bolinger, M. 2013. *Revisiting the long-term hedge value of wind power in an era of low natural gas prices.* Golden, CO: Lawrence Berkeley National Laboratory. Online at *http://emp.lbl.gov/sites/all/files/lbnl-6103e.pdf,* accessed on October 2, 2014.

Bloomberg New Energy Finance (BNEF). 2014. *2030 market outlook.* Online at *http://bnef.folioshack.com/document/v71ve0nkrs8e0,* accessed on September 15, 2014.

Cleetus, R., S. Clemmer, J. Deyette, and S. Sattler. 2014. *Climate game changer: How a carbon standard can cut power plant emissions in half by 2030.* Methodology and assumptions. Online at *www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/UCS-Carbon-Standards-Analysis-Methodology-and-Assumptions.pdf,* accessed on September 23, 2014.

Cleetus, R., S. Clemmer, and D. Friedman. 2009. *Climate 2030: A national blueprint for a clean energy economy.* Cambridge, MA: Union of Concerned Scientists. Online at *www.ucsusa.org/global_warming/solutions/ big_picture_solutions/climate-2030-blueprint.html,* accessed on September 19, 2014.

Energy Information Administration (EIA). 2014. Electricity data browser. Washington, DC: U.S. Department of Energy. Online at *www.eia.gov/electricity/data/browser/,* accessed on September 15, 2014.

Energy Information Administration (EIA). 2013. *Annual energy outlook 2013*. Washington, DC: U.S. Department of Energy.

Energy Information Administration (EIA). 2009. *Impacts of a 25-percent renewable electricity standard as proposed in the American Clean Energy and Security Act discussion draft*. Washington, DC: U.S. Department of Energy.

Environmental Protection Agency (EPA). 2014a. *Technical support document (TSD) for carbon pollution guidelines for existing power plants: Emission guidelines for greenhouse gas emissions from existing stationary sources: Electric utility generating units*, EPA-HQ-OAR-2013-0602. Washington, DC. Online at *www2.epa.gov/sites/production/files/2014-06/documents/20140602tsd-ghg-abatement-measures.pdf*, accessed on September 15, 2014.

Environmental Protection Agency (EPA). 2014b. *Clean Power Plan proposed rule: Alternative renewable energy approach: Technical support document*. Washington, DC. Online at *www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-alternative-renewable-energy-approach*, accessed on September 15, 2014.

Environmental Protection Agency (EPA). 2014c. *Carbon pollution emission guidelines for existing stationary sources: Electric utility generating units*. 79 FR 34829, pp. 34829–34958. Online at *https://federalregister.gov/a/2014-13726*, accessed on September 15, 2014.

Fagan, B., P. Lucklow, D. White, and R. Wilson. 2013. *The net benefits of increased wind power in PJM*. Cambridge, MA: Synapse Energy Economics, Inc.

GE Energy Consulting. 2014. *PJM Renewable integration study*. Schenectady, NY: General Electric International, Inc. Online at *http://pjm.com/~/media/committees-groups/task-forces/irtf/postings/pris-executive-summary.ashx*, accessed on September 23, 2014.

Heeter, J., G. Barbose, L. Bird, S. Weaver, F. Flores-Espino, K. Kuskova-Burns, and R. Wiser. 2014. *A survey of state-level cost and benefit estimates of renewable portfolio standards*. Golden, CO: National Renewable Energy Laboratory. Online at *www.nrel.gov/docs/fy14osti/61042.pdf*, accessed on September 19, 2014.

International Renewable Energy Agency (IRENA). 2014. *REthinking Energy: Towards a new power system*. Online at *www.irena.org/rethinking/Rethinking_FullReport_web.pdf*, accessed on September 15, 2014.

Kann, S., M.J. Shiao, S. Mehta, C. Honeyman, N. Litvak, and J. Jones. 2014. *U.S. solar market insight report 2013*. Washington, DC: Solar Energy Industries Association.

Lawrence Berkeley National Laboratory (LBNL). 2013. Renewables portfolio standards resources. Online at *http://emp.lbl.gov/rps*, accessed on September 15, 2014.

Melillo, J.M., T.C. Richmond, and G.W. Yohe. 2014. *Climate change impacts in the United States: The Third National Climate Assessment*. doi:10.7930/J0Z31WJ2. Washington, DC: U.S. Global Change Research Program. Online at *http://nca2014.globalchange.gov/*, accessed on September 23, 2014.

Mercurio, A. 2013. *Natural gas and renewables are complements, not competitors*. Washington, DC: Energy Solutions Forum, Inc.

National Renewable Energy Laboratory (NREL). 2012a. *Renewable electricity futures study*. NREL/TP-6A20-52409. Golden, CO. Online at *www.nrel.gov/analysis/re_futures/*, accessed on September 15, 2014.

National Renewable Energy Laboratory (NREL). 2012b. *Integrating wind and solar energy in the U.S. bulk power system: Lessons from regional integration studies*. Golden, CO. Online at *http://variablegen.org/wp-content/uploads/2012/11/55830-LessonsfromEWITSandWWSIS.pdf*, accessed on September 19, 2014.

Quarrier, R., and D. Farnsworth. 2014. *Tracking renewable energy for the U.S. EPA's Clean Power Plan*. San Francisco, CA: Center for Resource Solutions. Online at *www.resource-solutions.org/pub_pdfs/Tracking%20Renewable%20Energy.pdf*, accessed on September 20, 2014.

Solar Energy Industries Association (SEIA). 2014. Solar energy facts: 2013 year in review. Washington, DC. Online at *www.seia.org/sites/default/files/YIR%202013%20SMI%20Fact%20Sheet.pdf*, accessed on September 15, 2014.

Synapse Energy Economics. 2011. *Beyond business as usual*. Cambridge, MA. Online at *www.synapse-energy.com/Downloads/SynapseReport.2011-11.CSI.BBAU-2011.11-037.pdf*, accessed on September 19, 2014.

Union of Concerned Scientists (UCS). 2014. *Renewable energy on regional power grids can help states meet federal carbon standards*. Cambridge, MA. Online at *www.ucsusa.org/renewablesandregionalgrids*, accessed on September 19, 2014.

Union of Concerned Scientists (UCS). 2013. *How renewable electricity standards deliver economic benefits*. Cambridge, MA. Online at *www.ucsusa.org/assets/documents/clean_energy/Renewable-Electricity-Standards-Deliver-Economic-Benefits.pdf*, accessed on September 15, 2014.

Union of Concerned Scientists (UCS). 2009. *Clean power, green jobs*. Cambridge, MA. Online at *www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_energy/Clean-Power-Green-Jobs-25-RES.pdf*, accessed on October 2, 2014.

Wiser, R., and M. Bolinger. 2014. *2013 wind technologies market report*. Washington DC: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Online at *http://eetd.lbl.gov/sites/all/files/2013_wind_technologies_market_report_final3.pdf*, accessed on September 22, 2014.

Union of Concerned Scientists

FIND THIS DOCUMENT ONLINE: **www.ucsusa.org/renewablesandcleanpowerplan**

The Union of Concerned Scientists puts rigorous, independent science to work to solve our planet's most pressing problems. Joining with citizens across the country, we combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe, and sustainable future.

NATIONAL HEADQUARTERS
Two Brattle Square
Cambridge, MA 02138-3780
Phone: (617) 547-5552
Fax: (617) 864-9405

WASHINGTON, DC, OFFICE
1825 K St. NW, Suite 800
Washington, DC 20006-1232
Phone: (202) 223-6133
Fax: (202) 223-6162

WEST COAST OFFICE
500 12th St., Suite 340
Oakland, CA 94607-4087
Phone: (510) 843-1872
Fax: (510) 843-3785

MIDWEST OFFICE
One N. LaSalle St., Suite 1904
Chicago, IL 60602-4064
Phone: (312) 578-1750
Fax: (312) 578-1751

WEB: www.ucsusa.org

PRINTED ON RECYCLED PAPER USING VEGETABLE-BASED INKS

© OCTOBER 2014 UNION OF CONCERNED SCIENTISTS

Union of
Concerned Scientists
Science for a Healthy Planet and Safer World

December 1, 2014

To: Administrator Gina McCarthy
cc: Janet McCabe, Acting Assistant Administrator, Office of Air and Radiation;
Joseph Goffman, Associate Assistant Administrator & Senior Counsel, Office of Air and Radiation

Docket ID No. EPA-HQ-OAR-2013-0602

Proposed Clean Power Plan for Existing Power Plants

Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; Proposed Rule Vol. 79, Federal Register, No. 117, Wednesday, June 18, 2014 Environmental Protection Agency 40 CFR Part 60.

Environmental Protection Agency, EPA Docket Center (EPA/DC), Mailcode 28221T, Attention Docket ID No. OAR–2013-0602, 1200 Pennsylvania Avenue, NW, Washington, DC 20460.

Submitted via email to A-and-R-Docket@epa.gov

Dear Administrator McCarthy,

The Union of Concerned Scientists (UCS) commends the Environmental Protection Agency (EPA) for issuing a draft carbon pollution standard for existing fossil-fired power plants under the authority of the Clean Air Act (CAA) section 111(d). The EPA's draft Clean Power Plan (CPP), released on June 2, 2014 and published in the Federal Register on June 18, 2014, will help ensure reductions in power plant carbon dioxide (CO_2) emissions and a transition to cleaner generation sources. This standard is a critical first step in helping to slow the pace of climate change and limit its impacts.

We appreciate the opportunity to submit comments on this proposal and hope to see our views incorporated in the final standard when it is issued in June 2015. UCS is the nation's leading science-based nonprofit working for a healthy planet and a safer world. We work on behalf of our more than 450,000 supporters and network of nearly 18,000 scientists to advance public awareness of both the science of climate change and the solutions available to help lower emissions and mitigate some of the worst impacts of climate change.

UCS strongly supports the EPA's efforts to regulate carbon emissions from existing fossil fuel-fired power plants under the CAA. The EPA's actions are firmly grounded in science. The threat posed by unchecked climate change, which is driven primarily by carbon emissions from human activities, has been clearly articulated by numerous national and international scientific organizations, including the U.S. National Academy of Sciences[1], the U.S. Global Change Research Program,[2] and the Intergovernmental Panel on Climate Change.[3] In 2012, CO_2 emissions from power plants were the largest single source of U.S. CO_2 emissions, responsible for approximately 38 percent of these emissions.[4] Taking action to reduce emissions from the electricity sector is therefore crucial to our overall efforts to tackle climate change.

We take this opportunity to provide detailed comments on several issues raised by the proposal published in the Federal Register on June 18, 2014, in the Notice of Data Availability (NODA) issued on October 28, 2014, and in associated Technical Support Documents (TSDs). We would particularly like to call your attention to our comments on an approach to strengthening the renewable energy provisions of the Clean Power Plan. We recommend modifications to EPA's approaches that would nearly double EPA's 2030 renewables target from 12 percent to 23 percent of U.S. electricity sales by 2030. UCS modeling shows that strengthening the renewables building block to these levels is affordable and would increase the total emissions reductions achieved by the CPP from 30 percent to approximately 40 percent below 2005 levels by 2030.

We request that the EPA take these comments into consideration as it works to finalize the Clean Power Plan by June 1, 2015.

Sincerely,

On behalf of the Union of Concerned Scientists:

Kenneth Kimmell, *President*

Prepared by:

Rachel Cleetus
Rachel Cleetus
Senior Climate Economist

Steve Clemmer
Steve Clemmer
Director, Energy Research & Analysis

Jeff Deyette
Asst. Director, Energy Research & Analysis

Brenda Ekwurzel
Brenda Ekwurzel
Senior Climate Scientist

JulieMcNamara
Julie McNamara
Energy Research Associate

Jeremy Richardson
Senior Energy Analyst

JHRogers
John Rogers
Senior Energy Analyst

---

[1] G8+5 Academies' Joint Statement: Climate Change and the transformation of energy technologies for a low carbon future. 2009. http://www.nationalacademies.org/includes/G8+5energy-climate09.pdf. UCS incorporates by reference all of the materials cited in these comments and ask that they be included in the official record of this proceeding.

[2] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

[3] Intergovernmental Panel on Climate Change. 2014. Fifth assessment synthesis report. Online at http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_LONGERREPORT.pdf

[4] U.S. Environmental Protection Agency. 2014. Inventory of US Greenhouse Gas Emissions and Sinks, 1990-2012. http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Main-Text.pdf

Executive Summary of UCS Technical Comments

1. **Strong Support for the Clean Power Plan**
    - UCS supports the Clean Power Plan as a significant opportunity to achieve cost-effective emissions reductions in the power sector, which is the single largest source of U.S. CO2 emissions, and help slow the pace of climate change.
    - UCS supports the flexible framework in the draft rule, including a role for renewable energy and energy efficiency, which puts states in a leadership role in deciding how best to make cost-effective emission reductions. However, UCS analysis and expertise in the power sector lead us to the conclusion that there are significant opportunities to strengthen the rule, especially by increasing the contribution from renewable energy.
    - We commend the EPA for the extensive stakeholder process it has conducted leading up to the release of the draft rule, and for its continued outreach to all affected parties including through this comment period. We strongly support the timeline to finalize the rule by June 1, 2015, and the deadlines for state compliance.
2. **Climate Science Imperative to Act**
    - According to the Third National Climate Assessment, scientific evidence "unequivocally shows that our climate is changing and that the warming of the past 50 years is primarily due to human-induced emissions of heat-trapping gases."[1] The Intergovernmental Panel on Climate Change Fifth Assessment Report states that many of the observed changes such as the warming of the atmosphere and ocean, loss of snow and ice and sea level rise are "unprecedented", and that a continued rise in emissions will increase the risk of "severe, pervasive and irreversible impacts for people and ecosystems."[2]
    - In light of the urgent need to cut our global warming emissions to help slow the pace of climate change and limit its impacts, UCS strongly recommends that the EPA finalize a strong rule to cut carbon emissions from power plants in June 2015 as part of a national effort to limit U.S. emissions and provide communities more time to prepare.
    - UCS also notes that a strong Clean Power Plan is critical to ensuring a robust U.S. contribution to global efforts to limit emissions, including delivering on the upper end of the range of the 26 to 28 percent reduction in 2005 levels of net U.S. GHG emissions by 2025 announced by the Obama Administration in its joint climate change announcement with China.

---

[1] Melillo, J. M., T.C. Richmond, and G. W. Yohe (Eds.) 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2. Online at http://nca2014.globalchange.gov/.

[2] Intergovernmental Panel on Climate Change (IPCC). 2014. Fifth Assessment Synthesis Report. Online at http://ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_LONGERREPORT.pdf.

3. The Best System of Emissions Reductions (BSER)

- UCS supports the scope of, and flexibility in, the BSER for the Clean Power Plan, which reflects the many cost-effective options available to reduce power sector carbon emissions.

- UCS opposes the option of setting the BSER as only the first two building blocks, i.e. increasing the efficiency of existing coal-fired power plants and shifting power generation from existing coal-fired power plants to underutilized natural gas combined cycle (NGCC) plants, because that would exclude the potential for renewables and efficiency to deliver significantly greater emissions reductions at reasonable cost.

- We especially support the flexible choices provided to states, the inclusion of a role for renewable energy and energy efficiency in reducing emissions, the option to form multi-state compliance plans, and the inclusion of market-based emissions trading approaches—all of which will help drive down emissions at a lower cost.

- We recommend that the EPA strengthen, and regularly update, the CPP to reflect the full potential of affordable real-world emission reduction opportunities, and commensurate with the urgent need to address climate change. Our analysis shows that emission reductions of at least 40 percent below 2005 levels by 2030 are technically and economically feasible, and this level therefore corresponds with the best system of emission reduction.[3]

4. Heat Rate Improvements: Building Block 1

- UCS supports the EPA's determination of a 6 percent heat rate improvement (HRI) at existing coal-fired power plants as part of the BSER because several recent engineering studies support the conclusion that this level is technically feasible and economically reasonable.

- UCS supports the EPA's methodology for determining the HRI potential at coal-fired power plants to reduce carbon emissions because studying the variability in heat rates across the fleet is a sound way to gauge the potential for HRI.

- UCS recommends including biomass and natural gas co-firing in setting the BSER because there are states and regions where these options are cost-effective.

5. Coal to Gas Switching: Building Block 2

- UCS supports using generation from excess capacity at existing NGCC plants to displace generation from coal and oil/gas steam units, as part of the Clean Power Plan's Building Block 2. The state re-dispatch targets set by the EPA are achievable in the 2020 timeframe, especially when accounting for the large number of coal units already planned for retirement between 2013 and 2020. However, given the growing evidence that an overreliance on natural gas poses significant and complex risks to consumers, public health, and the climate, we recommend the EPA consider ways to avoid incentivizing natural gas generation and overbuilding infrastructure at the expense of other cost-effective, lower carbon resource alternatives.

---

[3] Our analysis showed that simply strengthening the renewables building block, as described in detail in section 6, would result in an additional 10 percent increase in emission reductions above the 30 percent reduction from 2005 levels by 2030 that the proposed rule achieves.

- UCS recommends that the EPA maintain its proposed 70 percent target utilization rate for existing NGCC in determining the BSER for Building Block 2.

- UCS recommends that the EPA increase the amount of generation from under construction NGCC units that is incorporated in the BSER re-dispatch calculation. The EPA's assumption that 79 percent of the total generation from under construction NGCC plants (e.g., a 55 percent capacity factor out of a total 70 percent capacity factor) would be utilized to meet new demand—and is therefore unavailable for re-dispatch purposes—overestimates the generation from these units likely to be used for new power demand rather than replacing generation from retiring coal units. We recommend reversing the EPA's proposed allocation of generation from under construction NGCC units so that a capacity factor of 55 percent is available for re-dispatch purposes, and a capacity factor of 15 percent is unavailable.

- UCS recommends that the EPA use a regional—rather than state—method for determining potential for gas re-dispatch, noting that regionalization generally leads to lower costs and more accurately aligns with the construct and operation of power grids across the nation.

- UCS recommends that the EPA also set standards to directly curb methane emissions from the oil and gas sector and update its GWP to 34 to more accurately conform to the latest science.

6. Renewable Energy: Building Block 3

- UCS strongly supports the inclusion of renewable energy as a compliance option in the Clean Power Plan, but recommends modifications to strengthen Building Block 3 that would use the most up-to-date data on renewable energy, set renewable energy growth rates at levels already being achieved by leading states, incorporate full compliance with current state renewable electricity standards, and reflect expected renewable energy growth between 2013 and 2017. UCS analysis shows nearly doubling EPA's renewable target to 23 percent of U.S. electricity sales by 2030 is affordable and would lead to greater emission reductions. This level corresponds with the best system of emission reduction (BSER), in contrast with the EPA's proposal which is more of an "average system of emission reduction."

- UCS also recommends improvements to strengthen EPA's Alternative Approach including eliminating the technical potential benchmarks, relying primarily on economic potential to set state and regional targets, using more up-to-date renewable energy cost and performance assumptions, and reflecting regional differences and existing state commitments.
- UCS recommends using and, where necessary, expanding on existing regional renewable energy credit (REC) tracking systems as the most effective mechanism for tracking state compliance, accounting for interstate effects, and preventing double counting. We also recommend requiring adjustments to take into account the emissions reductions associated with voluntary renewable energy purchases (RECs or "green power") to preserve the integrity of that market and the emissions reductions sought by voluntary institutional, commercial, and private purchasers, allowing such consumers to achieve reductions beyond those required under statutes and regulations.
- UCS recommends the EPA include the emission reductions from new renewables in the emission rate formula as a more consistent and equitable approach with how natural gas fuel switching is treated in Building Block 2, and exclude existing renewable energy and at-risk nuclear generation if the EPA opts to change the formula, given that their emission reductions are already embedded in the baseline emissions and generation mix.
- UCS supports incentives for early action, prior to 2020, to encourage investments in renewables and energy efficiency after a state compliance plan has been approved by the EPA, as long as these incentives do not undermine the overall level of emissions reductions achieved by the CPP.

7. **Nuclear Power: Building Block 3**
   - UCS supports the EPA's proposal to include new nuclear reactors that are under construction in setting state emission reduction targets and for compliance, which is consistent with the EPA's treatment of new natural gas combined cycle plants and UCS's recommendation for new renewables that are under construction.
   - UCS recommends excluding existing "at-risk" nuclear generation from the formula for setting state emission reduction targets, as the number of at-risk reactors is limited, site specific, and will likely decline over time as natural gas and wholesale electricity prices rise.
   - UCS does not support allowing existing plants that may receive a license extension beyond 60 years to be counted as new generation for the purposes of compliance, given important safety issues that are outside of the EPA's jurisdiction.
8. **Energy Efficiency: Building Block 4**
   - UCS recommends that the EPA use a target for incremental annual energy efficiency of at least 2.0 percent of electricity sales for each state, based on inclusion of a broader suite

of energy efficiency policies, measures, and technologies in its calculation of state targets.

- UCS similarly recommends that the EPA use a target of at least 0.25 percent per year for the ramp-up rate, based on the broader suite of opportunities, and incorporate a differential approach for states at the lowest annual levels, to better reflect opportunities for states at low levels of efficiency development.

- UCS recommends that the EPA update its baseline year for energy efficiency targets to 2013 and update cost and performance assumptions for efficiency technologies and measures to reflect the most recent data on state-level energy efficiency programs, and incorporate a range of other strategies to ensure the integrity and effectiveness of Building Block 4, including with respect to interstate trading, voluntary actions, and improvements in transmission and distribution.

9. Regional and Market-Based Approaches to Compliance with the Clean Power Plan

- UCS supports the flexibility in the Clean Power Plan that allows states to comply with the emissions reductions requirements called for by the CPP on a regional or multi-state basis if they so choose because this can lead to lower cost emission reductions.

- We also support the inclusion of market-based approaches to compliance, including emissions trading programs, carbon caps and carbon revenue-raising options, as long as the emissions reductions achieved are equivalent to the state goals in the CPP.

- UCS recommends that EPA provide guidance, in the case of states that choose to use market-based approaches that generate carbon revenues, on using such revenues, in part, to support or retrain displaced workers, invest in renewable energy and energy efficiency programs, and provide assistance to low-income and environmental justice communities.

10. Timing of Implementation and Compliance Dates for the Clean Power Plan

- UCS supports the EPA's proposal for the implementation timeline of the Clean Power Plan, the deadlines for state and multi-state compliance plans, and the dates for compliance with interim and final state goals.

- We strongly recommend that the EPA review and update state goals and other aspects of the Clean Power Plan no later than 2025, to reflect technology improvements that can contribute to a Best System of Emission Reduction (BSER) determination and opportunities for cost-effective emissions reductions.

- UCS does not support a change in the glide path for emissions reductions that would potentially delay emissions reductions.

11. Need and Cost-effective Potential to Strengthen the Clean Power Plan

- Given the urgent need to cut global warming emissions, UCS recommends that the EPA ensure that the CPP achieves the full potential of cost-effective emissions reductions available in the power sector, and that these reductions take place in a timely manner. Strengthening the CPP is also a critical component of the US contribution to international efforts to cut global emissions and slow the pace of climate change.

- Based on our analysis, we recommend several ways to cost-effectively strengthen the Clean Power Plan in keeping with the BSER criteria, including by:

    - Increasing the contribution from the renewable energy and energy efficiency building blocks;

    - Implementing a change in the goal computation formula to ensure that new and incremental renewable energy (RE), energy efficiency (EE) and nuclear generation explicitly replaces generation from fossil fuel-fired sources, which is a better representation of the BSER and consistent with the treatment of incremental NGCC; simultaneously, we recommend a formula change to remove existing generation resources (renewable energy and "at risk" nuclear energy) from the denominator of the formula used to calculate state goals since the associated emission reductions are already embedded in the baseline emissions and generation mix.

    - Including both the generation and emissions impacts of new NGCC units in the state goal calculation;

    - Ensuring that there are no changes to the 2020-2029 glide path that result in a delay in the interim and final goals for emissions reductions achieved by the CPP.

12. Environmental and Economic Justice Concerns

- UCS recognizes that, unless state compliance plans include specific worker transition provisions, the proposed standard for carbon emissions at existing power plants may have disproportionately negative impacts among certain coal-heavy geographic regions, coal-dependent communities, and coal-related workers.

- UCS recommends that the EPA work in conjunction with other federal and state agencies to leverage existing programs and resources that can be brought to bear in addressing impacts to coal communities and assisting displaced workers. States should consider a variety of policy mechanisms, both within the context of state compliance plans and through complementary policies enacted by state legislatures, to address these needs.

- UCS recommends that EPA require states to conduct environmental justice analyses of their compliance plans, and provide guidance to states on how to assess changes in criteria pollutants, water quality, and other environmental damage that may result from their compliance plans and assess the potential impacts on neighboring or downwind communities.[4]

- UCS recommends that states prioritize the development of renewable energy resources and the expansion of energy efficiency programs in overburdened and impacted communities, including low-income, minority, disadvantaged, and coal-heavy populations.

13. Guidance to States

- UCS recommends that the EPA provide clear guidance to states in developing their compliance plans to ensure that states are able to develop and submit robust plans in a timely way, and that such guidance cover issues such as treatment of certain energy options, best practices, methodologies, non-compliance penalties, processes, and options for addressing worker transition and environmental justice concerns.

---

[4] For example, the EPA should integrate the technical guidance in Plan EJ 2014 into its guidance for state compliance plans for the CPP to help states comply with the requirement for an environmental justice analysis of those plans. (EPA. N.d. Plan EJ 2014. Online at http://www.epa.gov/environmentaljustice/plan-ej/)

Table of Contents

Executive Summary of UCS Technical Comments 1

1. Strong Support for the Clean Power Plan 14
   - 1.1. The Clean Power Plan represents an historic opportunity to cut power sector emissions. 14
   - 1.2. The proposed Clean Power Plan is flexible and cost-effective. 16
   - 1.3. The EPA must strengthen and finalize the Clean Power Plan by June 2015 16
2. Climate Science Imperative to Act 17
   - 2.1. Carbon emissions are driving climate change with accelerating pace. 17
   - 2.2. Future risks of catastrophic climate outcomes add urgency for emissions reductions... 18
   - 2.3. Climate change impacts in the U.S. are growing. 19
3. The Best System of Emissions Reductions (BSER) 21
   - 3.1. UCS supports the inclusion of cost-effective "outside the fence line" approaches, including renewable energy and energy efficiency, to reduce carbon dioxide emissions..... 22
   - 3.2. UCS supports the flexibility inherent in the proposed framework that allows states to decide how best to meet the standard. 22
   - 3.3. The reduction targets proposed by the EPA are insufficient to meet the level of reductions required by the scale of the climate problem. 22
   - 3.4. UCS recommends that the EPA clarify the look-back provisions of the Clean Air Act and review and update the standard appropriately. 23
   - 3.5. UCS supports strengthening the emission reduction targets for the states. 23
   - 3.6. UCS recommends establishing the BSER based on the most recent generation and technology cost and performance data available. 23
   - 3.7. UCS recommends that the EPA improve the consistency in the emissions rate formula by treating Building Blocks 3 and 4 similar to Building Block 2. 24
   - 3.8. UCS recommends that the EPA include market-based approaches, such as emissions trading programs or carbon fees, in the definition of the BSER for the Clean Power Plan.. 24
4. Heat Rate Improvements: Building Block 1 25
   - 4.1. UCS supports the EPA estimate of the potential for HRI across the coal fleet as appropriately conservative. 25
   - 4.2. UCS supports the EPA's contention that a 6 percent HRI target is technically plausible on a fleet-wide basis. 25
   - 4.3. UCS concludes that a 6 percent HRI is cost effective on a fleet-wide basis. 26

4.4. UCS supports the EPA's concept of considering heat rate variability to estimate potential for HRI from plant operation and maintenance. 26

4.5. UCS recommends that the EPA include biomass co-firing as part of the BSER. 27

5. Coal to Gas Switching: Building Block 2 28

5.1. UCS supports using generation from excess capacity at existing NGCC plants to displace generation from coal and oil/gas steam units, as part of the Clean Power Plan's Building Block 2. 28

5.2. The EPA should consider ways to avoid incentivizing natural gas generation and overbuilding infrastructure at the expense of other cost-effective, lower carbon resource alternatives. 30

5.3. UCS recommends that the EPA maintain its proposed 70 percent target utilization rate for existing NGCC in determining the BSER for Building Block 2. 31

5.4. UCS recommends that the EPA increase the amount of generation from under construction NGCC units that is incorporated in the BSER re-dispatch calculation. 32

5.5. UCS recommends that the EPA use a regional method for determining potential for gas re-dispatch, noting that regionalization generally leads to lower costs and more accurately aligns with the construct and operation of power grids across the nation. 33

5.6. UCS recommends that the EPA also set standards to directly curb methane emissions from the oil and gas sector, the second largest industrial contributor to greenhouse gas emissions. 33

5.7. UCS recommends that the EPA update its assumed global warming potential (GWP) for methane. 34

6. Renewable Energy: Building Block 3 35

6.1. UCS strongly supports including renewable energy as a compliance option. 35

6.2. The EPA's proposed renewable energy targets fall well short of the BSER. 37

6.3. UCS recommends strengthening the renewable energy building block by adopting the UCS Demonstrated Growth Approach. 39

6.4. UCS recommends that the EPA, if it adopts its Alternative Approach, eliminate the technical potential benchmarks, rely primarily on economic potential to set state and regional targets, use updated renewable energy cost and performance assumptions, and reflect regional differences and existing state commitments. 50

6.5. UCS recommends the EPA use and, where necessary, expand on existing regional renewable energy credit (REC) tracking systems for compliance with the CPP and to help prevent double counting. 65

6.6. UCS recommends the EPA set renewable energy targets at the state level, but allow states to comply at a regional level. 68

6.7. UCS supports the EPA's proposed approach for counting emissions reductions from new and incremental renewable energy, nuclear energy, and energy efficiency, and for only allowing new and incremental hydro to count for compliance. 68

6.8. UCS recommends that the EPA include incentives for early action. 69

6.9. UCS recommends that the EPA use the most recent renewable generation data available, include renewable energy projects that are under construction through 2016, and assume states with RESs at least meet their mandatory targets. 69

7. Nuclear Power: Building Block 3 70

7.1. UCS supports the EPA's inclusion of new nuclear reactors that are under construction in setting state emission reduction targets and for compliance. 71

7.2. UCS recommends that the EPA exclude existing "at-risk" nuclear generation from the formula for setting state emission reduction targets. 71

7.3. UCS recommends that the EPA not allow any existing nuclear reactors that receive a license extension beyond 60 years to be counted as new generation for the purposes of compliance. 77

8. Energy Efficiency: Building Block 4 78

8.1. UCS recommends that the EPA include a broader suite of existing energy efficiency policies, measures, and technologies, including building codes, state appliance efficiency standards, and combined heat and power. 80

8.2. UCS recommends that the EPA use a target for incremental annual energy efficiency of at least 2.0 percent of electricity sales for each state, based on inclusion of the broader suite of energy efficiency policies discussed above. 80

8.3. UCS recommends that the EPA update its baseline year for energy efficiency targets to 2013, in place of 2012. 82

8.4. UCS recommends that the EPA use a target ramp-up rate of at least 0.25 percent per year, and incorporate a differential approach that assumes that states currently at the lowest annual levels rise more quickly to the target annual levels, to better reflect opportunities for states at low levels of efficiency development. 82

8.5. UCS recommends that the EPA update its cost and performance assumptions for efficiency technologies and measures to reflect the most recent data on state-level energy efficiency programs. 82

8.6. UCS recommends that the EPA incorporate a range of other strategies to ensure the integrity and effectiveness of Building Block 4, including with respect to credit for efficiency actions in net-importing states, accounting for voluntary energy efficiency actions, prohibitions against double-counting, and credit for improvements in transmission and distribution. 84

9. Regional and Market-Based Approaches to Compliance with the Clean Power Plan 86
   - 9.1. UCS supports the EPA's inclusion of regional compliance options as a cost-effective, proven way to provide numerous benefits. 86
   - 9.2. UCS recommends that the EPA provide clear guidance to enable more states and regions to take advantage of the benefits of multi-state compliance options, should they so choose. 87
   - 9.3. UCS supports the inclusion of market-based approaches to demonstrate compliance and recommends that the EPA offer additional guidance on these options. 88
   - 9.4. UCS recommends that the EPA provide guidance for the use of carbon revenues generated under market-based approaches. 89
   - 9.5. UCS recommends that EPA require that multi-state compliance plans contain some key elements to ensure their robustness. 90

10. Timing of Implementation and Compliance Dates for the Clean Power Plan 91
    - 10.1. UCS supports the EPA's timeline for implementing the Clean Power Plan as fair. 91
    - 10.2. UCS does not support changing the trajectory of emissions reductions to weaken near-term targets, given that it would send the wrong market signal, and be contrary to climate goals. 92
    - 10.3. UCS recommends that the EPA commit to reviewing and updating the Clean Power Plan by 2025. 92
    - 10.4. UCS supports the EPA's proposal for tracking of state compliance plan performance and true-up provisions, and recommends that the EPA require annual tracking and regular true-ups. 93

11. Need and Cost-effective Potential to Strengthen the Clean Power Plan 95
    - 11.1. Increasing the contribution from renewable energy and energy efficiency. 95
    - 11.2. UCS recommends that the EPA appropriately account for the emission reductions from displacement of fossil-fired generation sources by incremental renewable energy and energy efficiency. 96
    - 11.3. UCS recommends that the EPA appropriately account for emissions changes from substituting existing fossil-fired generation with new natural gas generation. 98
    - 11.4. UCS supports ensuring that the 2020-2029 glide path for state goals for emissions reductions remains as it is in the draft proposal and is not delayed in any way. 99

11.5. UCS recommends that the EPA remove existing generation resources (renewable energy and nuclear energy) from the denominator of the formula used to calculate state goals. 100

11.6. UCS recommends that the EPA strengthen the CPP as a critical component of the U.S. contribution to international climate efforts. 100

12. Environmental and Economic Justice Concerns 102

12.1. UCS recommends that the EPA emphasize—and provide guidance to states on—the potential for job creation and economic development from investments in renewable energy and energy efficiency and in supporting industries, especially manufacturing. 103

12.2. UCS recommends that the EPA require that states assess impacts of their compliance plans on workers and communities that will be disproportionately affected. 103

12.3. UCS recommends that the EPA highlight—provide guidance to states on considering—a variety of policy mechanisms, both within the context of state compliance plans and through complementary policies enacted by state legislatures, to retrain workers and invest in economic diversification. 104

12.4. UCS recommends that the EPA engage with other federal agencies on addressing worker transition concerns. 106

12.5. UCS recommends that the EPA work with stakeholders to help protect workers as the rule is implemented. 106

12.6. UCS recommends that the EPA require states to conduct an environmental justice analysis of their compliance plans. 107

12.7. UCS recommends that the EPA offer states data, methodology, and tools to conduct effective EJ analyses. 107

12.8. UCS supports prioritizing the development of renewable energy and energy efficiency in overburdened communities as part of state compliance plans. 107

12.9. UCS recommends that the EPA encourage states to solicit input on state compliance plans from a wide variety of stakeholders. 108

13. Guidance to States 109

Appendix 1. ReEDS Methodology 112

Methodology and assumptions for UCS modeling of strengthening the EPA's Clean Power Plan: Increasing renewable energy use will achieve greater emission reductions. 112

Scenarios 112

Assumptions 113

References 119

Appendix 2. State and Regional Renewable Energy Generation under the UCS Demonstrated Growth Approach, 2017 to 2030 121

1. Strong Support for the Clean Power Plan

- **UCS supports the Clean Power Plan as a significant opportunity to achieve cost-effective emissions reductions in the power sector, which is the single largest source of U.S. CO_2 emissions, and help slow the pace of climate change.**

- **UCS supports the flexible framework in the draft rule, including a role for renewable energy and energy efficiency, which puts states in a leadership role in deciding how best to make cost-effective emission reductions. However, UCS analysis and expertise in the power sector lead us to the conclusion that there are significant opportunities to strengthen the rule, especially by increasing the contribution from renewable energy.**

- **We commend the EPA for the extensive stakeholder process it has conducted leading up to the release of the draft rule, and for its continued outreach to all affected parties including through this comment period. We strongly support the timeline to finalize the rule by June 1, 2015, and the deadlines for state compliance.**

1.1. The Clean Power Plan represents an historic opportunity to cut power sector emissions.

The Clean Power Plan is being promulgated in the context of the biggest shift in the U.S. power sector has experienced in the last half century. Our nation's dependence on coal-fired power is decreasing as aging and polluting power plants are becoming increasingly uncompetitive relative to cleaner generation sources. Coal power accounted for more than half of our nation's electricity supply as recently as 2008 but had declined to just 39 percent by 2013. Since 2009, utilities have announced plans to close or convert to natural gas more than 430 coal generators in 37 states. These retirements of coal-burning plants total approximately 70,000 megawatts (MW) of power capacity, or about 20 percent of the total 2008 U.S. coal fleet.[5]

A combination of market and policy factors is driving these changes. The cost of coal is rising, and many coal generators have well-exceeded their intended design and economic lifespan. If older units are to remain in service, owners must add the cost of upgrading pollution controls to the cost of general refitting.[6] Other market factors making coal less attractive include low natural gas prices, reduced growth in electricity demand, and the falling costs of renewable energy. In addition, the successful implementation of state and federal policies supporting renewable energy and energy efficiency has cut into coal's market advantage over other power sources.[7]

---

[5] Fleischman, L., R. Cleetus, J. Deyette, S. Clemmer, and S. Frenkel. 2013. Ripe for retirement: An economic analysis of the U.S. coal fleet. *The Electricity Journal* 26(10):51-63. Online at dx.doi.org/10.1016/j.tej.2013.11.005.

[6] Cleetus, R., S. Clemmer, E. Davis, J. Deyette, J. Downing, and S. Frenkel. 2012. Ripe for retirement: The case for closing America's costliest coal plants. Cambridge, MA: Union of Concerned Scientists. Online at http://www.ucsusa.org/assets/documents/clean_energy/Ripe-for-Retirement-Full-Report.pdf.

[7] *Ibid.*

The electric power sector is the largest single contributor to U.S. global warming pollution, accounting for approximately one-third of total emissions and nearly 40 percent of carbon dioxide (CO_2) emissions. And coal plants alone were responsible for almost 80 percent of electric sector CO_2 emissions in 2011. The EPA's draft Clean Power Plan provides a flexible framework under which states will cut CO_2 emissions by choosing from among a number of emissions-reducing options. These options include increasing generation from renewable energy, nuclear, and natural gas power plants, and investing in energy efficiency at fossil fuel plants and in buildings and industry.

As coal power's dominance wanes, the United States has a valuable opportunity to accelerate the transition to an economy powered by clean, affordable, and reliable energy sources, while protecting public health and cutting CO_2 emissions. In the last few years, electricity from natural gas power plants has largely stepped in where coal plants have backed out. Driven largely by low prices, the natural gas power industry's share of the U.S. electricity mix increased nearly 30 percent from 2008 to 2013. This surge in natural gas generation has resulted in important near-term benefits, including reduced harmful air and water emissions from power plants, less water use, greater flexibility of the power grid, and renewed economic development in gas-rich regions of the country. However, a number of complex risks—economic, environmental, public health, and climate risks—accompany the country's increasing dependence on natural gas.

Ramping up investments in renewable energy and energy efficiency is critical to ensuring a transition to a diversified, clean electricity system. These clean energy resources are already ramping up quickly across the country, demonstrating that they can deliver affordable, reliable, and low-carbon power. Advances in technology and decreases in costs are driving tremendous growth—wind power capacity, for example, increased by 75 percent and solar capacity by 473 percent from 2009 to 2013.[8,9] The national average cost of wind power has dropped more than 60 percent since 2009, making it competitive with new fossil fuel plants in many regions.[10] Solar photovoltaic system costs fell by about 40 percent from 2008 to 2012, and by another 15 percent in 2013.[11,12]

Nationally, the share of non-hydro renewable resources doubled from 3 percent in 2008 to more than 6 percent of the U.S. power supply in 2013. Numerous studies have found that with existing technologies and measures, renewable energy can reliably and affordably increase to much

---

[8] American Wind Energy Association (AWEA). 2014. U.S. wind industry annual market report 2013. Washington, DC: AWEA.

[9] Solar Energy Industries Association (SEIA). 2014. Solar energy facts: 2013 year in review. Washington, DC: SEIA. Online at www.seia.org/sites/default/files/YIR%202013%20SMI%20Fact%20Sheet.pdf.

[10] Wiser, R., and M. Bolinger. 2014. 2013 wind technologies market report. Washington DC: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Online at http://eetd.lbl.gov/sites/all/files/2013_wind_technologies_market_report_final3.pdf.

[11] Kann, S., M.J. Shiao, S. Mehta, C. Honeyman, N. Litvak, and J. Jones. 2014. U.S. solar market insight report 2013. Washington, DC: Solar Energy Industries Association.

[12] Barbose, G., N. Darghouth, S. Weaver, and R. Wiser. 2013. Tracking the sun VI: An historical summary of the installed price of photovoltaics in the United States from 1998 to 2012, LBNL-6350E. Berkeley, CA: Lawrence Berkeley National Laboratory. Online at http://emp.lbl.gov/sites/all/files/lbnl-6350e.pdf.

higher levels—reaching up to 25 to 30 percent of the total U.S. power supply or more—over the next two decades. Indeed, many states and regions are already achieving these levels today.[13]

1.2. The proposed Clean Power Plan is flexible and cost-effective.

The flexible framework of the Clean Power Plan provides significant opportunities for states to make smart energy choices to help them reduce emissions cost-effectively. The Best System of Emission Reduction (BSER) proposed by the EPA takes advantage of the many affordable choices to help reduce emissions by shifting to cleaner generation sources. Importantly, it includes a role for renewable energy and energy efficiency. Choosing a path leading to a diverse supply of low-carbon sources—a mix made up primarily of renewable energy and energy efficiency but also including a more balanced role for natural gas—will help ensure a more consumer-friendly, resilient, and diversified electricity system, deliver cost-effective CO_2 emissions reductions, and minimize the risks that an over-reliance on natural gas would present. The energy choices we make in the next few years will have major consequences for our economy, health, and climate for many decades to come.

1.3. The EPA must strengthen and finalize the Clean Power Plan by June 2015

Our analysis shows that there are significant opportunities to strengthen the Clean Power Plan, particularly by increasing the role of renewables in cutting emissions (see section 6). We urge the EPA take advantage of this and other opportunities to strengthen and improve the rule so that it delivers emission reductions of at least 40 percent below 2005 levels by 2030. We also call upon the EPA to ensure that it is finalized by June 1, 2015, in accordance with the Presidential Memorandum on Power Sector Carbon Pollution Standards.[14]

---

[13] Union of Concerned Scientists (UCS). 2013. Ramping up renewables. Cambridge, MA: UCS. Online at www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_energy/Ramping-Up-Renewables-Energy-You-Can-Count-On.pdf.

[14] The White House. 2013. Presidential Memorandum — Power Sector Carbon Pollution Standards. Online at http://www.whitehouse.gov/the-press-office/2013/06/25/presidential-memorandum-power-sector-carbon-pollution-standards.

2. Climate Science Imperative to Act

- **According to the Third National Climate Assessment, scientific evidence "unequivocally shows that our climate is changing and that the warming of the past 50 years is primarily due to human-induced emissions of heat-trapping gases."[15] The Intergovernmental Panel on Climate Change Fifth Assessment Report states that many of the observed changes such as the warming of the atmosphere and ocean, loss of snow and ice and sea level rise are "unprecedented", and that a continued rise in emissions will increase the risk of "severe, pervasive and irreversible impacts for people and ecosystems."[16]**

- **In light of the urgent need to cut our global warming emissions to help slow the pace of climate change and limit its impacts, UCS strongly recommends that the EPA finalize a strong rule to cut carbon emissions from power plants in June 2015 as part of a national effort to limit U.S. emissions and provide communities more time to prepare.**

- **UCS also notes that a strong Clean Power Plan is critical to ensuring a robust U.S. contribution to global efforts to limit emissions, including delivering on the upper end of the range of the 26 to 28 percent reduction in 2005 levels of net U.S. GHG emissions by 2025 announced by the Obama Administration in its joint climate change announcement with China.**

2.1. Carbon emissions are driving climate change with accelerating pace.

Evidence of the heat-trapping role of carbon dioxide (CO_2) in the atmosphere was established in 1859 and by the end of that century the discovery emerged that fossil fuel emissions could cause a shift in Earth's climate.[17] The first confirmation that these emissions were already changing Earth's temperature emerged during the 1930s.[18]

The accelerating pace of emissions after these discoveries is alarming, with over half emitted since 1970 of the total human CO_2 emissions between 1750 and 2010.[19] The annual atmospheric CO_2 increase (2.9 ppm) over 2012-2013 was the highest over the 1984 to 2013 period of record.[20] Accelerating emissions has occurred despite the worldwide trend, since 1850, in the mix of primary energy supply shifting away from less carbon intensive fuels from primarily biomass to primarily coal to more oil and gas in the mix.[21] The latest tracking for each country's share of CO_2 emissions ranks China (27 percent) and the United States (17 percent) as the top two in 2011.[22] The bulk of 2012 U.S. heat-trapping emissions was in the form of CO_2 (82 percent) with nearly a third of all U.S. emissions that year coming from electricity generation (32 percent).[23] Carbon standards aimed at reducing emissions from existing U.S. power plants tackles one of the largest current sources of global CO_2 emissions in the world.

---

[15] Melillo, J. M., T.C. Richmond, and G. W. Yohe (Eds.) 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2. Online at http://nca2014.globalchange.gov/.

[16] Intergovernmental Panel on Climate Change (IPCC). 2014. Fifth Assessment Synthesis Report. Online at http://ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_LONGERREPORT.pdf.

[17] Fleming, J.R. 1998. Historical Perspectives on Climate Change, Oxford University Press.

[18] Callendar, G.S. 1938. The artificial production of carbon dioxide and its influence on temperature. Quarterly J. Royal Meteorological Society 64:223-240.

[19] IPCC, 2014: Summary for Policymakers, In: Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

2.2. Future risks of catastrophic climate outcomes add urgency for emissions reductions.

Certain catastrophic climate outcomes are a growing risk unless substantial progress in global heat-trapping emissions occurs. The northern permafrost soil organic carbon pool is estimated to be around 1672 petagrams carbon (PgC).[24] This is larger than the anthropogenic budget of around 1,000 PgC emissions to stay below a global mean temperature rise of 2°C above the 1861–1880 period; half (445-585 PgC) has already been emitted by 2011.[25]

Keeping this region cold enough to prevent the release of these vast stores of carbon in the form of methane (CH_4) and CO_2, trapping heat and warming Earth even faster, is a key factor in the urgency for substantial emissions reductions. Reasons include the processes that lead to amplified warming in the Arctic which pose risks of increased permafrost degradation rates.[26] The loss of the upper few meters of permafrost is projected to decrease 37 percent to 81 percent by the end of this century under RCP2.6 and RCP8.5 future scenarios respectively.[27] Carbon released from permafrost is irreversible for millennia.[28]

---

[20] WMO. 2014. WMO Greenhouse Gas Bulletin: The State of Greenhouse Gases in the Atmosphere Based on Global Observations through 2013. World Meteorological Organization. ISSN 2078-0796.

[21] Blanco G. et al., Chapter 5: Drivers, Trends, and Mitigation, in Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

[22] U.S. Energy Information Administration. Indicators CO_2 Emissions Tables for 2011. Online at http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=90&pid=44&aid=8&cid=regions&syid=2007&eyid=2011&unit=MTCDPP.

[23] EPA. 2014. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2012. U.S. Environmental Protection Agency, Washington D.C. The EPA 430-R-14-003.

[24] Kuhry, P., Grosse, G., Harden, J. W., Hugelius, G., Koven, C. D., Ping, C.-L., Schirrmeister, L. and Tarnocai, C. 2013. Characterisation of the Permafrost Carbon Pool. Permafrost Periglac. Process., 24:146–155. doi: 10.1002/ppp.1782

[25] Collins, M., R. Knutti, J. Arblaster, J.-L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver and M. Wehner. 2013. Long-term Climate Change: Projections, Commitments and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[26] Lawrence, D.M., Slater, A.G., Tomas, R.A., Holland, M.M., and Deser, C. 2008. Accelerated Arctic land warming and permafrost degradation during rapid sea ice loss. Geophys. Res. Lett. 35 DOI 10.1029/2008GL033985

[27] IPCC. 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[28] *Ibid.*

Another catastrophic climate outcome, that is irreversible for millennia, is ice sheet collapse.[29] Long before total collapse, significant ice sheet shrinking would transform coastlines of the world to a degree that would be unrecognizable to many coastal residents of today. Paleoclimate evidence from the last interglacial period, around 130,000 years ago, occurred with the combined shrinking of the perimeter of the Greenland ice sheet and the West Antarctic Ice Sheet with an associated sea level rise of more than 4 to 6 meters above current sea level.[30] Today's CO_2 levels in the atmosphere are much higher than when these changes occurred over the last interglacial. At 6 meters additional sea level rise, south Florida and the Mississippi Delta regions of Louisiana would be severely inundated as well as large portions of other coastlines around the world.[31]

2.3. Climate change impacts in the U.S. are growing.

Already, people living in the U.S. are exposed to climate change impacts that vary in severity depending on the season, location, socioeconomic factors as well as local, regional, and national resilience policies.[32] Land ice and warming oceans both contribute to global sea level rise with the former at a much higher increasing pace than the latter.[33,34] This combined with local land elevation shifts and the loss of natural barriers has increased so-called "nuisance flooding" in areas of the U.S. with more than 300 percent increase (Norfolk, VA, San Francisco, CA, and Washington DC) to more than 900 percent increase (Baltimore, MD, and Annapolis, MD) in the number of flood days in recent years (2007–2013) compared to around 50 years earlier (1957–1963).[35] The future risk of nuisance flooding is directly tied to the rate at which the U.S. and the world choose the pace of emissions going forward. Emissions really matter to many coastal communities. For example, in Annapolis, MD, which currently experiences nearly 50 tidal flood events per year, the community could face over 220 such events under an intermediate-low scenario or over 380 such events under the highest emissions scenario.[36] Since there are only 365 days a year, that means tidal flooding twice a day at current Annapolis locations or for all practical purposes—inundation.

The growing risk of extreme events that lead to too much water (or snow) or too little water (and associated consequences) have cost lives, property and at times transformed local communities when severe enough to permanently displace a critical number of residents. The fundamental consequence of more water vapor in the atmosphere from global warming, has led to an increase in precipitation volume in the heaviest annual events, in Alaska and the Continental U.S. (e.g., Northeast (71 percent); Midwest (37 percent).[37]

---

[29] *Ibid.*

[30] Overpeck J.T., B.L. Otto-Bliesner, G.H. Miller, D.R. Muhs, R.B. Alley, and J.T. Kiehl. 2006. Paleoclimatic Evidence for Future Ice-Sheet Instability and Rapid Sea-Level Rise. Science:311:1747-1750.

[31] Overpeck, J.T. and J.L. Weiss. 2009. Projections of future sea level becoming more dire. PNAS. 106: 21461–21462.

[32] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds. 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. 841 pp. doi:10.7930/J0Z31WJ2.

[33] Church, J.A., N.J. White, L.F. Konikow, C.M. Domingues, J.G. Cogley, E. Rignot, J.M. Gregory, M.R. van den Broeke, A.J. Monaghan, and I. Velicogna. 2011. Revisiting the Earth's sea-level and energy budgets from 1961 to 2008. Geophys. Res. Lett. 38. doi:10.1029/2011GL048794.

[34] Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Appendix 3: Climate Science Supplement. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program. 735-789. doi:10.7930/J0KS6PHH.

[35] Sweet, W., J. Park, J. Marra, C. Zervas, S. Gill. 2014. Sea Level Rise and Nuisance Flood Frequency Changes around the United States. NOAA Technical Report NOS CO-OPS 073 and online at http://www.noaanews.noaa.gov/stories2014/20140728_nuisanceflooding.html.

[36] Spanger-Siegfried, E., M.F. Fitzpatrick, and K. Dahl. 2014. Encroaching tides: How sea level rise and tidal flooding threaten U.S. East and Gulf Coast communities over the next 30 years. Cambridge, MA: Union of Concerned Scientists.

Higher temperatures increase soil and surface water evaporation and plant transpiration rates leading to increased drought risk in some regions, seasons or time periods.[38] Warmer temperatures in the Western U.S. have brought earlier snowmelt leaving high mountain forests hotter and drier, especially comparing the dry La Niña years compared with La Niña years decades earlier, increasing the risk of large wildfires.[39] Federal fire suppression costs, in 2012 dollars, have increased from around $440 million in 1985 to around 1.7 billion in 2013.[40]

Significantly reducing U.S. existing power plant emissions in the next decade and beyond can help reduce the risks of negative consequences from climate change in the U.S. and the world. As part of the global effort to reduce emissions, in 2009 the U.S. committed to reducing emissions 17 percent below 2005 levels by 2020,[41] and recently announced a commitment to further reduce emissions 26 to 28 percent below 2005 levels by 2025.[42] These commitments would put the U.S. on a path to the goal of reducing emissions by at least 80 percent by 2050, a goal consistent with international agreements. Scientists conclude that to meet international goals to limit warming to 2°C above preindustrial levels,[43] the world must stay within a budget of around 1,000 PgC emissions.[44] For the U.S. to make good on those commitments, the power sector will need to cut emissions by more than the estimated reductions from the Clean Power Plan of 30 percent below 2005 levels by 2030.

---

[37] Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Ch. 2: Our Changing Climate. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe. Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT.

[38] *Ibid.*

[39] Westerling A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfireactivity. Science 313:940–943.

[40] Cleetus, R., and K. Mulik. 2014. Playing with fire: How climate change and development patterns are contributing to the soaring costs of western wildfires. Cambridge, MA: Union of Concerned Scientists.

[41] United States. 2010. Copenhagen Accord submission. Online at http://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/unitedstatescphaccord_app.1.pdf

[42] The White House. 2014. U.S.-China Joint Announcement on Climate Change and Clean Energy Cooperation. Fact sheet. Online at http://www.whitehouse.gov/the-press-office/2014/11/11/fact-sheet-us-china-joint-announcement-climate-change-and-clean-energy-c

[43] National Research Council. 2010. Limiting the magnitude of future climate change. Washington, DC: National Academies Press.

[44] Collins, M., R. Knutti, J. Arblaster, J.-L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver and M. Wehner. 2013. Long-term Climate Change: Projections, Commitments and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

3. The Best System of Emissions Reductions (BSER)

- **UCS supports the scope of, and flexibility in, the BSER for the Clean Power Plan, which reflects the many cost-effective options available to reduce power sector carbon emissions.**
- **UCS opposes the option of setting the BSER as only the first two building blocks, i.e. increasing the efficiency of existing coal-fired power plants and shifting power generation from existing coal-fired power plants to underutilized natural gas combined cycle (NGCC) plants, because that would exclude the potential for renewables and efficiency to deliver significantly greater emissions reductions at reasonable cost.**
- **UCS supports the flexible choices provided to states, the inclusion of a role for renewable energy and energy efficiency in reducing emissions, the option to form multi-state compliance plans, and the inclusion of market-based emissions trading approaches—all of which will help drive down emissions at a lower cost.**
- **UCS recommends that the EPA strengthen, and regularly update, the CPP to reflect the full potential of affordable real-world emission reduction opportunities, and commensurate with the urgent need to address climate change. Our analysis shows that emission reductions of at least 40 percent below 2005 levels by 2030 are technically and economically feasible, and this level therefore corresponds with the best system of emission reduction.**[45]

UCS applauds the EPA for proposing a flexible standard for carbon emissions at existing power plants, and for including the potential for renewable energy and energy efficiency as compliance mechanisms. The BSER defined by the EPA takes advantage of multiple cost-effective options already in use and available across the country to help shift our electricity system from more fossil fuel-intensive generation sources toward cleaner, less polluting options. It also allows states to choose and combine the options they prefer, including joining together with other states to form multi-state compliance plans.

The proposed standard, however, would deliver approximately 30 percent reductions in carbon emissions from the power sector by 2030, a level that is not commensurate with the scale of the climate problem and is inconsistent with reaching at least 80 percent reductions by 2050. UCS therefore urges strengthening the standard and offers specific ways in which the proposal can achieve emissions reductions of at least 40 percent below 2005 levels by 2030. These include an improved methodology for determining the state targets for renewable energy (Building Block 3), using the most recent generation and technology cost and performance data in calculating state targets, and improving the EPA's formula for setting the emission rate targets. Strengthening the CPP will provide public health, environmental and economic benefits, alongside helping to reduce heat trapping emissions.

---

[45] Our analysis showed that simply strengthening the renewables building block, as described in detail in section 6, would result in an additional 10 percent increase in emission reductions above the 30 percent reduction from 2005 levels by 2030 that the proposed rule achieves.

3.1. UCS supports the inclusion of cost-effective "outside the fence line" approaches, including renewable energy and energy efficiency, to reduce carbon dioxide emissions.

A framework that recognizes the interconnected nature of the electricity grid will capture greater emissions reductions at a lower cost per ton, particularly by including non-emitting renewable energy and reducing electricity demand through end-use energy efficiency.[46] Renewables have grown tremendously in recent years as costs decline. From 2009 to 2013, wind capacity increased by 75 percent[47] and solar capacity by 473 percent.[48] Average costs of wind power dropped more than 60 percent since 2008; solar photovoltaic systems costs fell by about 40 percent from 2008 to 2012, and another 15 percent in 2013.[49,50]

3.2. UCS supports the flexibility inherent in the proposed framework that allows states to decide how best to meet the standard.

States may use the building blocks in any combination or at any level of ambition they choose, so long as they meet the state-specific targets established by the EPA's determination of the BSER. This is critical to the cost-effectiveness of the emissions reductions achieved by the standard.[51] It also puts states in the driver's seat in deciding which options suit their specific circumstances.

3.3. The reduction targets proposed by the EPA are insufficient to meet the level of reductions required by the scale of the climate problem.

With Americans already facing worsening risks of climate impacts, clearly outlined in the National Climate Assessment,[52] the EPA's Clean Power Plan is an important step forward in the effort to limit those risks, discussed at length in section 2 of our comments. We offer a systematic and consistent methodology for calculating more aggressive targets for renewable energy generation (see section 6) that achieves 10 percent greater emission reductions than the EPA's proposed method, i.e., emission reductions of 40 percent below 2005 levels by 2030. Our methodology is a logical outgrowth of the EPA's approaches but does not rely on applying state renewable electricity standards (RES) to states without such policies, and it achieves greater reductions in emissions in all regions and in all but four states.

---

[46] Cleetus, R., S. Clemmer, J. Deyette, and S. Sattler. 2014. Climate Game Changer: How a carbon standard can cut power plant emissions in half by 2030. Cambridge, MA: Union of Concerned Scientists. Online at http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/Carbon-Standards-Analysis-Union-of-Concerned-Scientists.pdf.

[47] American Wind Energy Association (AWEA). 2014. U.S. wind industry annual market report 2013. Washington, DC: AWEA.

[48] Solar Energy Industries Association (SEIA). 2014. Solar energy facts: 2013 year in review. Washington, DC: SEIA. Online at www.seia.org/sites/default/files/YIR%202013%20SMI%20Fact%20Sheet.pdf, accessed on September 15, 2014.

[49] Kann, S., M.J. Shiao, S. Mehta, C. Honeyman, N. Litvak, and J. Jones. 2014. U.S. solar market insight report 2013. Washington, DC: Solar Energy Industries Association.

[50] Barbose, G., N. Darghouth, S. Weaver, and R. Wiser. 2013. Tracking the sun VI: An historical summary of the installed price of photovoltaics in the United States from 1998 to 2012, LBNL-6350E. Berkeley, CA: Lawrence Berkeley National Laboratory. Online at http://emp.lbl.gov/sites/all/files/lbnl-6350e.pdf, accessed on September 15, 2014.

[51] See, for example: Fowlie, M., L. Goulder, M. Kotchen, S. Borenstein, J. Bushnell, L. Davis, M. Greenstone, C. Kolstad, C. Knittel, R. Stavins, M. Wara, F. Wolak, C. Wolfram. 2014. An economic perspective on the EPA's Clean Power Plan: Cross-state coordination key to cost-effective CO_2 reductions. *Science*, 346(6211): 815-816. DOI: 10.1126/science.1261349.

[52] Melillo, J. M., T.C. Richmond, and G. W. Yohe (Eds.) 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2. Online at http://nca2014.globalchange.gov/.

3.4. UCS recommends that the EPA clarify the look-back provisions of the Clean Air Act and review and update the standard appropriately.

The EPA carbon standard is only the first step in curbing harmful emissions, and that emissions must continue to decline beyond 2030. The agency should clarify the look-back provisions of the Clean Air Act, specifically designating when the targets will be updated to reflect new information. We recommend that the agency review and update the standard at least every eight years, with the first update by 2025. With the costs and performance of low carbon technologies improving rapidly, this type of review will be essential for ensuring we achieve the full potential for cost-effective emission reductions. We note the experience of the nine states participating in the Regional Greenhouse Gas Initiative (RGGI), which recently tightened the cap[53] on carbon emissions based on new data on cost and impacts of the program. Based on the recent dramatic growth of renewable energy and corresponding precipitous drop in costs, it seems reasonable to assume that the economic calculations will have changed by the end of the compliance period, and that additional cost-effective reductions in CO_2 should be included in the BSER.

3.5. UCS supports strengthening the emission reduction targets for the states.

The EPA offers several alternatives in establishing the BSER for each state and solicits comments on all of them. For example, the EPA offers a second option for compliance levels and times, which establishes less stringent emissions reduction targets but requires compliance by 2025[54]. The EPA also lays out several options for establishing the BSER using combinations of the building blocks. UCS strongly opposes the option of setting the BSER as only the first two building blocks[55] (p.34836), because it would exclude the potential for renewables and efficiency to deliver significantly greater emissions reductions at reasonable cost.

3.6. UCS recommends establishing the BSER based on the most recent generation and technology cost and performance data available.

By the time the rule is finalized, the EPA should have access to final 2014 data and the agency should use that information in establishing state targets. Building from the most recent data on renewable generation is critical, given the rapid growth in deployment of these resources in recent years. In addition, the agency should use the most recent cost and performance data for renewable energy technologies, such as wind and solar. The EPA's assumptions should be updated to reflect new NREL resource assessments, more recent data from actual projects, and credible studies projecting continued cost reductions and technology improvements through 2030. These studies and data sources are discussed in more detail in section 6. The data and calculations in these technical comments are based on data from 2013, unless otherwise noted.

---

[53] http://www.rggi.org/design/overview/cap

[54] https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating#p-240

[55] https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating#p-743

3.7. UCS recommends that the EPA improve the consistency in the emissions rate formula by treating Building Blocks 3 and 4 similar to Building Block 2.

The formula the EPA developed for calculating the adjusted emissions rate is inconsistent in its treatment of zero-carbon generating sources and does not adequately account for expected emissions reductions from developing those resources. See section 11 for our specific guidance on improving the formula and other issues raised by the October 28, 2014, Notice of Data Availability.[56]

3.8. UCS recommends that the EPA include market-based approaches, such as emissions trading programs or carbon fees, in the definition of the BSER for the Clean Power Plan.

The EPA should provide specific guidance to states on how to demonstrate equivalence for market based approaches, so that they can take advantage of those options if they so choose. Market-based approaches can provide flexibility and low cost options to reduce emissions, as well as revenues for addressing worker transition and environmental justice considerations (see sections 9 and 12).

---

[56] http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-notice-data-availability

4. Heat Rate Improvements: Building Block 1

- **UCS supports the EPA's determination of a 6 percent heat rate improvement (HRI) at existing coal-fired power plants as part of the BSER because several recent engineering studies support the conclusion that this level is technically feasible and economically reasonable.**
- **UCS supports the EPA's methodology for determining the HRI potential at coal-fired power plants to reduce carbon emissions because studying the variability in heat rates across the fleet is a sound way to gauge the potential for HRI.**
- **UCS recommends including biomass and natural gas co-firing in setting the BSER because there are states and regions where these options are cost-effective.**

4.1. UCS supports the EPA estimate of the potential for HRI across the coal fleet as appropriately conservative.

The EPA considered two HRI components: operational best practices and equipment upgrades. The agency reviewed the technical literature and analyzed real-world data to determine the potential for HRI. It concluded that best practices for operations and maintenance (O&M) could lead to a 4 percent improvement and that equipment upgrades could achieve another 2 percent. As described[57] in the Technical Support Document, the EPA reduced its estimates below what it found to be technically and economically feasible to allow for differences among individual EGUs and across states. Thus, according to the agency's own analysis, the overall 6 percent HRI target is conservative.

4.2. UCS supports the EPA's contention that a 6 percent HRI target is technically plausible on a fleet-wide basis.

The EPA identified a number of measures that could improve efficiencies at coal-fired power plants and quantified the level of improvement each could achieve.[58] While some stakeholders have raised concerns about the viability of this level of HRI (especially for newer plants) several technical studies[59] support the conclusion that higher improvements are possible and cost effective over the entire fleet. Resources for the Future (RFF) analyzed[60] performance data for coal plants in 2008, sorted by boiler type, and found the average HRI would be 5.5 percent if each plant matched the best performing (top 10 percent) plants in its class. RFF concluded that the 6 percent figure is technically plausible and economically reasonable. The National Energy Technology Lab has laid out a vision for improving the nation's coal fleet from 32.5 percent efficiency to 36 percent.[61]

---

[57] EPA. 2014. Technical Support Document for GHG Abatement Measures.

[58] EPA. 2014. Technical Support Document for GHG Abatement Measures. Table 2-3.

[59] See, for example: Sargent & Lundy LLC. 2009. Coal-fired power plant heat rate reductions. Chicago: Report SL-009597.

[60] Burtraw, D. http://www.rff.org/centers/climate_and_electricity_policy/Pages/6-Increasing-Efficiency-at-Coal-Plants.aspx

[61] NETL 2010. Improving the efficiency of coal-fired power plants for near-term greenhouse gas emissions reductions.

4.3. UCS concludes that a 6 percent HRI is cost effective on a fleet-wide basis.

Recognizing that economic calculations vary from plant to plant, UCS agrees with the EPA that a six percent HRI across the coal fleet is cost effective. Moreover, UCS emphasizes that retirement of older, less efficient, and dirtier coal plants will help states achieve their targets. The average age of the nation's coal fleet is 38 years,[62] compared to an average expected lifetime of 30 years. By 2013, 24 GW of coal-fired generation, with an average age of 51 years,[63] had already been announced for retirement. By 2020, the start of the compliance period, more existing plants will have outlasted their expected lifetimes. Thus for some EGUs, investments in HRI may not make sense because of the age of the facility. For others, however, HRI may make sense and may even extend their useful lifetimes.[64] States will have to consider their own individual generating fleets to determine the most cost-effective way to meet their targets. Case law affirms that reduced usage of covered entities (including retirement) is consistent with complying with air pollution regulations.[65] States have been given maximum flexibility to comply with their individual state targets, but as noted by the RGGI states,[66] that flexibility should not extend to setting the targets. (See section 5 for a deeper discussion of coal retirements as part of our comments on Building Block 2.)

4.4. UCS supports the EPA's concept of considering heat rate variability to estimate potential for HRI from plant operation and maintenance.

The EPA looked at variability of heat rates in coal fired power plants as a method to assess the potential for improvements in operation and maintenance (O&M). Heat rate is the principal metric by which the quality of electric generation is measured, and high variability indicates potential for improvement.[67] UCS supports this concept as a valid way of gauging the performance of EGUs. The EPA's methodology also adjusted for ambient and operating conditions, which can affect heat rates at individual units. Adjusting for boiler size, design, vintage, and presence of pollution control equipment, an independent analysis of heat rate variability over 25 years concluded that a 6 percent HRI represents the upper bound of technical feasibility, ignoring costs.[68] Their findings support the EPA's claim that costs are low, at least for modest HRI of 1-2 percent. That analysis also noted factors influencing heat rates, including poor management support, lack of engineering expertise on site, the threat of New Source Review, and fuel cost pass-through to customers, can limit implementation of HRI. The Sierra

---

[62] Cleetus, R., et al. 2012. Ripe for retirement: the case for closing America's costliest coal plants. Cambridge, MA: Union of Concerned Scientists.

[63] Fleischman, L., R. Cleetus, J. Deyette, S. Clemmer, and S. Frenkel. 2013. Ripe for retirement: An economic analysis of the U.S. coal fleet. *The Electricity Journal* 26(10):51-63. Online at dx.doi.org/10.1016/j.tej.2013.11.005.

[64] Ellerman, D. 1998. Note on the seemingly indefinite extension of power plant lives, a panel contribution. *The Energy Journal* 19(2):129.

[65] https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating#p-872.

[66] See technical comments submitted by the RGGI states on the Clean Power Plan (Docket ID EPA-HQ-OAR-2013-0602).

[67] EPA. 2014. Technical Support Document for GHG Abatement Measures, p.2-26.

[68] Linn et al. 2014. Regulating greenhouse gasses of coal power plants under the Clean Air Act. Journal of the Association of Environmental and Resource Economists, 1:97-134.

Club has similarly studied variability in heat rates over 11 years and concludes[69] that the EPA should set the HRI target at 10 percent.

4.5. UCS recommends that the EPA include biomass co-firing as part of the BSER.

If developed in a sustainable manner, biomass can supply increasing amounts of low carbon electricity, as discussed in more detail in section 6.4.1.1. Recent modeling by NREL,[70] EIA,[71] and UCS,[72] shows that biomass co-firing is a cost-effective option in certain cases and does represent a portion of additional renewable energy sources expected to come on line by 2030.

We agree, as the EPA noted in the draft CPP, that the source of the biomass is critical to ensuring that co-firing decreases total CO_2 emissions on a lifecycle basis. The EPA notes that the CO_2 reduction potential for biomass co-firing depends on a wide variety of factors, including land-use practices, the type of biomass, moisture content, and the type of coal it replaces.[73] Cost estimates are highly site-specific, and may be driven primarily by collection and transportation costs, in particular the distance over which the feedstock must be transported. UCS suggests that biomass co-firing be evaluated on a regional or state basis for inclusion in the BSER (see section 6). Finally, biomass co-firing can also help stimulate local and regional economies, particularly in the Midwest,[74] the Southeast, and in Appalachia.[75]

The EPA's ongoing work on the *Framework for Assessing Biogenic Carbon Dioxide for Stationary Sources* is critical to understanding the role that sustainable biomass can play in reducing GHG emissions, and establishing the safeguards necessary to ensure robust accounting of lifecycle emissions and other impacts from the use of biomass.[76] UCS will continue to review and assess the findings in the latest report as it undergoes review by the Science Advisory Board.[77]

---

[69] See comments to be submitted by the Sierra Club on the Clean Power Plan (Docket ID EPA-HQ-OAR-2013-0602).

[70] National Renewable Energy Laboratory (NREL). 2012a. Renewable electricity futures study, NREL/TP-6A20-52409. Golden, CO: NREL. Online at www.nrel.gov/analysis/re_futures/, accessed on September 15, 2014.

[71] Energy Information Administration (EIA). 2014. *Annual Energy Outlook 2014*. Washington, DC: U.S. Department of Energy. Online at http://www.eia.gov/forecasts/aeo/pdf/0383(2014).pdf

[72] Cleetus, R., S. Clemmer, J. Deyette, and S. Sattler. 2014. Climate Game Changer: How a carbon standard can cut power plant emissions in half by 2030. Cambridge, MA: Union of Concerned Scientists. Online at http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/Carbon-Standards-Analysis-Union-of-Concerned-Scientists.pdf.

[73] EPA. 2014. Technical Support Document for GHG Abatement Measures, p.6-15.

[74] Martinez et al. 2011. A bright future for the heartland. Cambridge, MA: Union of Concerned Scientists.

[75] Richardson, L. J., R. Cleetus, S. Clemmer, and J. Deyette. Economic impacts on West Virginia from projected future coal production and implications for policymakers. *Environmental Research Letters* 9(2): 024006. doi:10.1088/1748-9326/9/2/024006.

[76] EPA. 2014. Framework for Assessing Biogenic CO_2 Emissions from Stationary Sources. United States Environmental Protection Agency, Office of Air and Radiation Office of Atmospheric Programs, Climate Change Division. Washington, DC. Online at http://www.epa.gov/climatechange/ghgemissions/biogenic-emissions.html

[77] http://www.epa.gov/climatechange/downloads/Biogenic-CO2-Emissions-Memo-111914.pdf

5. Coal to Gas Switching: Building Block 2

- **UCS supports using generation from excess capacity at existing NGCC plants to displace generation from coal and oil/gas steam units, as part of the Clean Power Plan's Building Block 2. The state re-dispatch targets set by the EPA are achievable in the 2020 timeframe, especially when accounting for the large number of coal units already planned for retirement between 2013 and 2020. However, given the growing evidence that an overreliance on natural gas poses significant and complex risks to consumers, public health, and the climate, we recommend the EPA consider ways to avoid incentivizing natural gas generation and overbuilding infrastructure at the expense of other cost-effective, lower carbon resource alternatives.**

- **UCS recommends that the EPA maintain its proposed 70 percent target utilization rate for existing NGCC in determining the BSER for Building Block 2.**

- **UCS recommends that the EPA increase the amount of generation from under construction NGCC units that is incorporated in the BSER re-dispatch calculation. The EPA's assumption that 79 percent of the total generation from under construction NGCC plants (e.g., a 55 percent capacity factor out of a total 70 percent capacity factor) would be utilized to meet new demand—and is therefore unavailable for re-dispatch purposes—overestimates the generation from these units likely to be used for new power demand rather than replacing generation from retiring coal units. We recommend reversing the EPA's proposed allocation of generation from under construction NGCC units so that a capacity factor of 55 percent is available for re-dispatch purposes, and a capacity factor of 15 percent is unavailable.**

- **UCS recommends that the EPA use a regional—rather than state—method for determining potential for gas re-dispatch, noting that regionalization generally leads to lower costs and more accurately aligns with the construct and operation of power grids across the nation.**

- **UCS recommends that the EPA also set standards to directly curb methane emissions from the oil and gas sector and update its GWP to 34 to more accurately conform to the latest science.**

5.1. UCS supports using generation from excess capacity at existing NGCC plants to displace generation from coal and oil/gas steam units, as part of the Clean Power Plan's Building Block 2.

Increasing generation from excess capacity at existing natural gas power plants is a sensible and cost-effective near-term action for displacing generation from higher carbon emitting sources. When combusted in an efficient, combined-cycle (NGCC) power plant, natural gas emits approximately 800 pounds of CO_2 per megawatt-hour (MWh)—an amount some 50 to 60 percent less than the amount emitted from a typical new coal plant.[78] Burning natural gas instead of coal also results in a number of immediate public health and environmental co-benefits. Natural gas combustion releases much smaller amounts of soot and smog-forming pollutants, including nitrogen oxides, sulfur dioxide, and fine particulates, which contribute to asthma and a variety of other lung, and heart, conditions. Moreover, unlike coal, natural-gas-fired electricity generation does not emit appreciable levels of mercury, arsenic, and other toxic substances that can cause adverse neurological effects in children and other health problems.[79]

Utilities and power producers across the country are already increasing output from natural gas power plants largely to replace aging coal plants that have become less and less economic. As a result of abundant supplies and low prices, generation from natural gas increased by nearly 30 percent between 2008 and 2013; at which time natural gas accounted for 27 percent of the total U.S. power supply.[80] Even historically heavy coal power-producing states are demonstrating the ability to rapidly shift from coal to natural gas. For example, between 2008 and 2013, natural gas generation in Georgia increased from 10 percent to 34 percent of the state's power mix. Similar jumps in natural generation during this period occurred in more than a dozen states, including North Carolina (3 percent to 22 percent), Virginia (13 percent to 29 percent), Ohio (2 percent to 15 percent), and Pennsylvania (9 percent to 22 percent).[81]

Despite the recent shift toward natural gas, there is still plenty of excess capacity in the U.S. natural gas power fleet that can be used to displace the coal and oil/gas steam generation embedded in the state targets under Building Block 2. For example in 2012, the NGCC fleet experienced capacity factors averaging between 44 percent and 46 percent. That is well below the 85 percent or higher capacity factors at which NGCC units are capable of producing. In fact, a recent analysis by the Union of Concerned Scientists found that in nearly every NERC region[82], the capacity factor needed for existing NGCC plants to replace both coal units already planned for retirement and those units deemed economically vulnerable (105 gigawatts, or GW, of coal capacity in total) is well below 85 percent. On average across NERC regions, retiring coal can be replaced by boosting the existing NGCC national average capacity factor to about 58 percent.[83] All this evidence suggests that the state re-dispatch targets set by the EPA are achievable well within the 2020 timeframe, especially when accounting for the nearly 47 GW of coal units either already closed or planned for retirement between 2013 and 2020.

---

[78] National Energy Technology Laboratory. 2010. Cost and performance baseline for fossil energy plants, Volume 1: Bituminous coal and natural gas to electricity, Revision 2. DOE/NETL-2010/1397. Washington, DC: U.S. Department of Energy. Online at www.netl.doe.gov/energy-analyses/pubs/Bituminous%20Baseline_Final%20Report.pdf.

[79] Environmental Protection Agency (EPA). 2012a. Mercury: Basic information. Washington, DC: EPA. Online at www.epa.gov/mercury/about.htm. Clean Air Task Force. 2010. The toll from coal: An updated assessment of death and disease from America's dirtiest energy source. Boston, MA. Online at www.catf.us/resources/publications/view/138. Environmental Protection Agency. 2010. Federal implementation plans to reduce interstate transport of fine particulate matter and ozone; proposed rule. 40 CFR Parts 51, 52, 72, et al. Federal Register 75, August 2. Online at www.gpo.gov/fdsys/pkg/FR-2010-08-02/pdf/2010-17007.pdf. Gentner, B., and M. Bur. 2010. Economic damages of impingement and entrainment of fish, fish eggs, and fish larvae at the Bay Shore Power Plant. Silver Spring, MD: Gentner Consulting Group. Online at switchboard.nrdc.org/blogs/tcmar/BSSP.damages.final.pdf. National Research Council. 2010. Hidden costs of energy: Unpriced consequences of energy production and use. Washington, DC: National Academies Press. Online at www.nap.edu/catalog.php?record_id=12794. Trasande, L., P.J. Landrigan, and C. Schechter. 2005. Public health and economic consequences of methyl mercury toxicity to the developing brain. Environmental Health Perspectives 113(5):590–596. Online at www.ncbi.nlm.nih.gov/pmc/articles/PMC1257552/.

[80] Energy Information Administration. 2014. Electric power monthly Table 1.1. Washington, DC: U.S. Department of Energy. Online at www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_1_01.

[81] *Ibid.*

[82] The North American Electric Reliability Corporation (NERC) oversees reliability for a bulk power system that includes the United States and Canada. In this effort, NERC coordinates with eight regional entities to maintain and improve the reliability of the power system. These entities are composed of utilities, federal power agencies, rural cooperatives, independent power marketers, and end-use customers. For more information, see http://www.nerc.com.

5.2. The EPA should consider ways to avoid incentivizing natural gas generation and overbuilding infrastructure at the expense of other cost-effective, lower carbon resource alternatives.

Despite its potential near-term economic and carbon benefits, there is growing evidence that an overreliance on natural gas poses significant and complex risks to consumers, the economy, public health and safety, land and water resources, and to the climate. For example, while its smokestack emissions are significantly cleaner than coal's, the extraction, distribution, and combustion of natural gas present serious environmental, public health, and climate change challenges.[84]

Replacing coal plants with natural gas plants will likely reduce the amount of CO_2 emitted for each megawatt-hour of U.S. electricity generated; however, a number of recent studies have concluded that abundant natural gas will do little to reduce overall heat trapping emissions.[85] Extensive modeling of future scenarios has found that, in addition to replacing coal, increased reliance on natural gas could delay the deployment of clean renewable energy. As demand for electricity grows and generating capacity is added to the system to meet it, demand that could have been met by new renewable energy resources might instead be met by natural gas. As a result, total carbon emissions will fail to approach the level of reductions needed to meet U.S. targets. Under certain scenarios, global warming emissions may actually increase.

Direct smokestack pollutants are not the only global warming emissions associated with natural gas. The drilling and extraction of the fuel from wells, and its distribution in pipelines, also results in the leakage of methane—a primary component of natural gas that is 34 times stronger than carbon dioxide at trapping heat over a 100-year period and 86 times stronger over 20 years.[86] While there is still uncertainty about the precise quantity of these so-called fugitive methane emissions, preliminary studies and field measurements range from 1 to 9 percent of total natural gas production.[87] EPA should set standards to directly limit these methane emissions (see recommendation below).

---

[83] Fleischman, L., R. Cleetus, J. Deyette, S. Clemmer, and S. Frenkel. 2013. Ripe for Retirement: An Economic Analysis of the U.S. Coal Fleet. The Electricity Journal 26(10):51-63. Online at dx.doi.org/10.1016/j.tej.2013.11.005.

[84] Fleischman, Lesley, Sandra Sattler, and Steve Clemmer. Gas ceiling: Assessing the climate risks of an overreliance on natural gas for electricity. Cambridge, MA: Union of Concerned Scientists, September 2013. Online at http://www.ucsusa.org/assets/documents/clean_energy/climate-risks-natural-gas.pdf.

[85] Shearer, C., Bistline, J., Inman, M. and Davis, J.D. 2014. The effect of natural gas supply on US renewable energy and CO_2 emissions. Environmental Research Letters 9(9):1–8. Online at iopscience.iop.org/1748-9326/9/9/094008/.
Energy Modeling Forum (EMF). 2013. Changing the game?: Emissions and market implications of new natural gas supplies. Stanford, CA. Online at web.stanford.edu/group/emf-research/docs/emf26/Summary26.pdf.
Newell, R.G. and Raimi, D. 2014. Implications of shale gas development for climate change. Environmental Science & Technology 48(15):8360–8368. Online at pubs.acs.org/doi/abs/10.1021/es4046154.

[86] Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang. 2013. Anthropogenic and Natural Radiative Forcing. In: Climate

Over the long-term, natural gas power plants are far less attractive from a climate standpoint than cleaner and much lower-carbon alternatives such as energy efficiency and renewable energy. And continuing to increase the nation's dependence on natural gas—as EIA forecasts project under current policy and market conditions[88]—could ultimately undermine progress toward long-term climate emission reduction goals while delaying the transition to a diverse and truly low-carbon electric power system. Consequently, we recommend the EPA consider ways—within the Clean Power Plan and using other regulatory authority as appropriate—to avoid incentivizing natural gas generation and overbuilding infrastructure at the expense of other cost-effective, lower carbon resource alternatives.

5.3. UCS recommends that the EPA maintain its proposed 70 percent target utilization rate for existing NGCC in determining the BSER for Building Block 2.

We find that the 70 percent capacity factor is a reasonable benchmark for NGCC usage, since many of these plants were designed to run at much higher rates, above 85 percent.[89] Also, a regionalized approach to setting gas re-dispatch targets (see below) would help alleviate concerns that some stakeholders have raised about the infrastructure needed to provide higher volumes of natural gas to these plants.

Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. .

[87] Tollefson, J. 2013. Methane leaks erode green credentials of natural gas. Nature 493(7430):12. Online at www.nature.com/news/methane-leakserode-green-credentials-of-natural-gas-1.12123#/ref-link-5. Cathles, L.M., L. Brown, M. Taam, and A. Hunter. 2012. A commentary on "The greenhouse-gas footprint of natural gas in shale formations" by R.W. Howarth, R. Santoro, and A. Ingraffea. Climatic Change 113(2):525–535. Online at cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/FINAL%20Short%20Version%2010-4-11.pdf. Howarth, R.W., D. Shindell, R. Santoro, A. Ingraffea, N. Phillips, and A. Townsend-Small. 2012. Methane emissions from natural gas systems. Background paper prepared for the National Climate Assessment, reference number 2011–0003. Online at www.eeb.cornell.edu/howarth/Howarth%20et%20al.%20--%20National%20Climate%20Assessment.pdf. Petron, G., G. Frost, B.R. Miller, A.I. Hirsch, S.A. Montzka, A. Karion, M. Trainer, C. Sweeney, A.E. Andrews, L. Miller, J. Kofler, A. Bar-Ilan, E.J. Dlugokencky, L. Patrick, C.T. Moore, Jr., T.B. Ryerson, C. Siso, W. Kolodzey, P.M. Lang, T. Conway, P. Novelli, K. Masarie, B. Hall, D. Guenther, D. Kitzis, J. Miller, D. Welsh, D. Wolfe, W. Neff, and P. Tans. 2012. Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study. Journal of Geophysical Research: Atmospheres 117(D4). Online at onlinelibrary.wiley.com/doi/10.1029/2011JD016360/abstract. Skone, T. 2012. Role of alternative energy sources: Natural gas power technology assessment, DOE/NETL-2011/1536. Washington, DC: U.S. Department of Energy. Weber, C., and C. Clavin. 2012. Life cycle carbon footprint of shale gas: Review of evidence and implications. Environmental Science and Technology 46:5688–5695. Online at pubs.acs.org/doi/abs/10.1021/es300375n.

[88] Energy Information Administration (EIA). 2014a. Annual Energy Outlook 2014. Online at www.eia.gov/forecasts/aeo/.

[89] See, e.g., North American Electric Reliability Corp., 2008-2012 Generating Unit Statistical Brochure—All Units Reporting, http://www.nerc.com/pa/RAPA/gads/Pages/Reports.aspx; Higher Availability of Gas Turbine Combined Cycle, Power Engineering (Feb. 1, 2011), http://www.power-eng.com/articles/print/volume-115/issue-2/features/higher-availability-of-gas-turbine-combined-cycle.html.

5.4. UCS recommends that the EPA increase the amount of generation from under construction NGCC units that is incorporated in the BSER re-dispatch calculation.
EPA has assumed that under construction NGCC plants are being built mostly to meet new electricity demand. Assuming those plants operate at 70 percent capacity factor, the agency assumes that a larger portion (a 55 percent capacity factor, meaning 79 percent of a new plant's generation) meets new demand, while the remaining 15 percent is available to displace existing fossil. However, this overestimates the amount of generation that will be utilized to meet new power demand because many of these plants are being built to replace retiring coal generation deemed uneconomic[90] due to age, lack of pollution controls, and cheaper alternatives.

Of the nine states with under construction NGCC units incorporated into the Building Block 2 target methodology, all except for California have significant planned coal generator retirements scheduled between 2012 and 2018 (Table 5-1). In fact, the total capacity of planned coal retirements in these states outweighs the capacity of under construction NGCC plants by nearly a factor of 2 to 1 (16,366 MW vs 8,938 MW). In some case, these under construction NGCC units are being built explicitly to replace the generation from retiring coal plants. For example, the 620 MW NGCC plant that Kentucky Utilities is building at Cane Run will replace the generation from coal units the utility is retiring at its Cane Run, Green River, and Tyrone facilities.[91]

Table 5-1. Comparison of Under Construction NGCC Capacity in Building Block 2 with Capacity of Planned Coal Retirements, by State.

	Under Construction NGCC Capacity (MW)*	Planned Coal Retirement Capacity (MW)*
California	1,855	0
Colorado	200	690
Florida	1,157	1,062
Kentucky	640	3,187
Mississippi	150	877
North Carolina	2,249	2,409
Ohio	539	5,971
Virginia	1,928	2,114
Wyoming	220	56
Total	8,938	16,366

*Under construction NGCC capacity is based on data included in the EPA Clean Power Plan. Planned coal retirement capacity data is from: Fleischman, L., R. Cleetus, J. Deyette, S. Clemmer, and S. Frenkel. 2013. Ripe for Retirement: An Economic Analysis of the U.S. Coal Fleet. The Electricity Journal 26(10):51-63. Online at dx.doi.org/10.1016/j.tej.2013.11.005; updated as needed with information from SNL Energy.

---

[90] Cleetus, R., S. Clemmer, E. Davis, J. Deyette, J. Downing, and S. Frenkel. 2012. Ripe for retirement: The case for closing America's costliest coal plants. Cambridge, MA: Union of Concerned Scientists. Online at http://www.ucsusa.org/assets/documents/clean_energy/%20Ripe-for-Retirement-Full-Report.pdf.

[91] Bandyk, M. 2013. "Kentucky Utilities facing new controls at coal plant under EPA settlement". SNL Energy, January 2. Online at https://www.snl.com/InteractiveX/article.aspx?ID=16707547&KPLT=2.

While it is difficult to precisely determine how much generation from new NGCC capacity will go toward displacing retiring coal, it is clear that the EPA's estimate is overly conservative. As a result, we recommend reversing the EPA's proposed allocation of generation from under construction NGCC units by allocating a capacity factor of 55 percent as available for re-dispatch purposes (and a capacity factor of 15 percent as unavailable), instead of the 15 percent available (versus 55 percent unavailable) that is assumed in the draft proposal.

5.5. UCS recommends that the EPA use a regional method for determining potential for gas re-dispatch, noting that regionalization generally leads to lower costs and more accurately aligns with the construct and operation of power grids across the nation.

As described in the October 28, 2014, Notice of Data Availability, the EPA is soliciting comment on whether to define the targets for Building Block 2 on the basis of the regional availability of additional NGCC capacity up to the 70 percent capacity factor. UCS validates this methodology as a way of making the targets for Building Block 2 more equitable across states; it would increase targets for states with little existing NGCC capacity (such as West Virginia and Kentucky) and ameliorate targets for states with large excess capacity (such as Texas and Florida). A regional approach would also more consistently align with ongoing grid operations and electricity dispatch decisions. Finally, regionalization of the gas re-dispatch targets would be more consistent with how the EPA calculates the renewable energy building block targets. We note that while our proposed stronger renewable energy targets (see part 7) are developed on a bottom-up approach from the state level, they can be easily regionalized in a similar manner for consistency.

5.6. UCS recommends that the EPA also set standards to directly curb methane emissions from the oil and gas sector, the second largest industrial contributor to greenhouse gas emissions.

To ensure that fuel switching from coal to natural gas results in significant emission reductions under the CPP, the EPA should also simultaneously implement strong standards to reduce fugitive methane emission from the production and distribution of natural gas. The natural gas industry is the largest industrial source of methane emissions at 23 percent of the total, and emissions are projected to increase as a result of the hydraulic fracturing boom.[92] The Obama Administration's recently released multi-sector strategy to cut methane emissions from agriculture, landfills, coal mines, and oil and gas production is an important step to reduce the climate risks of natural gas.[93] A recent study by Clean Air Task Force, NRDC and the Sierra Club estimates that the EPA could reduce the sector's methane pollution in half in a just few years by issuing nationwide methane standards that require common sense, low-cost pollution controls for the sector's top emitting sources including: regular leak detection and repair programs from all equipment at wellheads and processing and distribution points, upgrading older equipment, and capturing any natural gas that is released instead of flaring or venting it.[94]

---

[92] EPA. 2014. Inventory of U.S. greenhouse gas emissions and sinks, 1990-2012. Online at http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Main-Text.pdf.

[93] White House. 2014. Climate action plan: Strategy to reduce methane emissions. Online at http://www.whitehouse.gov/sites/default/files/strategy_to_reduce_methane_emissions_2014-03-28_final.pdf.

5.7. UCS recommends that the EPA update its assumed global warming potential (GWP) for methane.

In its Regulatory Impact Analysis, the EPA assumes that methane has a GWP of 25 over 100 years,[95] as calculated in the IPCC's Fourth Assessment Report.[96] However, the recently released Fifth Assessment Report[97] puts that value at 34. This will allow a more accurate calculation (in terms of CO_2-equivalent) of avoided upstream methane emissions as a result of this rulemaking and other rules to directly regulate methane emissions.

---

[94] CATF, NRDC and Sierra Club. 2014. Waste Not: Common sense ways to reduce methane pollution from the oil and natural gas industry. Online at http://www.catf.us/resources/publications/files/WasteNot_Summary.pdf.

[95] EPA 2014. Regulatory Impact Analysis, p.3A-6.

[96] Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland. 2007. Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (Table 2.14).

[97] Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang. 2013. Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (Table 8.7).

6. Renewable Energy: Building Block 3

- **UCS strongly supports the inclusion of renewable energy as a compliance option in the Clean Power Plan, but recommends modifications to strengthen Building Block 3 that would use the most up-to-date data on renewable energy, set renewable energy growth rates at levels already being achieved by leading states, incorporate full compliance with current state renewable electricity standards, and reflect expected renewable energy growth between 2013 and 2017. UCS analysis shows nearly doubling EPA's renewable target to 23 percent of U.S. electricity sales by 2030 is affordable and would lead to greater emission reductions. This level corresponds with the best system of emission reduction (BSER), in contrast with the EPA's renewable energy proposal which is more of an "average system of emission reduction."**

- **UCS also recommends improvements to strengthen the EPA's Alternative Approach including eliminating the technical potential benchmarks, relying primarily on economic potential to set state and regional targets, using more up-to-date renewable energy cost and performance assumptions, and reflecting regional differences and existing state commitments.**

- **UCS recommends using and, where necessary, expanding on existing regional renewable energy credit (REC) tracking systems as the most effective mechanism for tracking state compliance, accounting for interstate effects, and preventing double counting. We also recommend requiring adjustments to take into account the emissions reductions associated with voluntary renewable energy purchases (RECs or "green power") to preserve the integrity of that market and the emissions reductions sought by voluntary institutional, commercial, and private purchasers, allowing such consumers to achieve reductions beyond those required under statutes and regulations.**

- **UCS recommends the EPA include the emission reductions from new renewables in the emission rate formula as a more consistent and equitable approach with how natural gas fuel switching is treated in Building Block 2, and exclude existing renewable energy and at-risk nuclear generation if the EPA opts to change the formula, given that their emission reductions are already embedded in the baseline emissions and generation mix.**

- **UCS supports incentives for early action, prior to 2020, to encourage investments in renewables and energy efficiency after a state compliance plan has been approved by the EPA, as long as these incentives do not undermine the overall level of emissions reductions achieved by the CPP.**

6.1. UCS strongly supports including renewable energy as a compliance option.

The EPA's decision to include renewable energy as an eligible compliance option for states to reduce power plant carbon emissions is sensible and meets the criteria for the BSER. Technologies such as wind and solar already deliver safe, reliable, and affordable power to millions of U.S. consumers, emit no carbon in their operation, and are an economically viable alternative to fossil fuels. All states have significant and diverse renewable energy resources that can be developed. And as a result of falling costs, advances in technology, and strong state policies, renewable energy technologies are in an excellent position to compete with the other emissions-reduction strategies allowed under the Clean Power Plan.

The U.S. power sector has experienced a tremendous growth in renewable energy, driven largely by advances in technology, decreases in costs, and state and federal policies. Wind capacity increased by 75 percent and solar capacity by 473 percent from 2009 to 2013.[98] The national average cost of wind power has dropped more than 60 percent since 2009, making it competitive with new fossil fuel plants in many regions.[99] Solar photovoltaic systems costs fell by about 40 percent from 2008 to 2012, and by another 15 percent in 2013.[100] Looking ahead, several studies project these two trends of improved technologies and reduced costs to continue.[101]

This growth in renewable energy has helped most utilities comply with their state RES requirements at little or no cost to consumers, and in some cases even providing them with net savings.[102] As highlighted in the EPA's GHG abatement measures technical support document (TSD), a recent federal government study, relying primarily on actual data from utilities and state regulators, found that between 2010 and 2012 the cost of complying with RESs in 25 states ranged from a net savings of 0.2 percent of retail rates to a net cost of 3.8 percent, with a weighted average cost of 0.9 percent.[103] The EPA also includes several other credible studies in the TSD that demonstrate the cost-effectiveness of increasing renewable energy at the state and regional level and highlight the recent cost reductions for wind and solar.[104]

---

[98] American Wind Energy Association (AWEA). 2014. U.S. wind industry annual market report 2013. Washington, DC: AWEA. Solar Energy Industries Association (SEIA). 2014. Solar energy facts: 2013 year in review. Washington, DC: SEIA. Online at www.seia.org/sites/default/files/YIR%202013%20SMI%20Fact%20Sheet.pdf, accessed on September 15, 2014.

[99] Wiser, R., and M. Bolinger. 2014. 2013 wind technologies market report. Washington, DC: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Online at http://eetd.lbl.gov/sites/all/files/2013_wind_technologies_market_report_final3.pdf, accessed on September 22, 2014.

[100] Kann, S., M.J. Shiao, S. Mehta, C. Honeyman, N. Litvak, and J. Jones. 2014. U.S. solar market insight report 2013. Washington, DC: Solar Energy Industries Association. Barbose, G., N. Darghouth, S. Weaver, and R. Wiser. 2013. Tracking the sun VI: An historical summary of the installed price of photovoltaics in the United States from 1998 to 2012, LBNL-6350E. Berkeley, CA: Lawrence Berkeley National Laboratory. Online at http://emp.lbl.gov/sites/all/files/lbnl-6350e.pdf, accessed on September 15, 2014.

[101] For example, see Bloomberg New Energy Finance (BNEF). 2014. 2030 market outlook. Online at http://bnef.folioshack.com/document/v71ve0nkrs8e0, accessed on September 15, 2014. International Renewable Energy Agency (IRENA). 2014. REthinking Energy: Towards a new power system. Online at www.irena.org/rethinking/Rethinking_FullReport_web.pdf, accessed on September 15, 2014. National Renewable Energy Laboratory (NREL). 2012a. Renewable electricity futures study, NREL/TP-6A20-52409. Golden, CO: NREL. Online at www.nrel.gov/analysis/re_futures/, accessed on September 15, 2014. Lantz, E., R. Wiser and M. Hand. 2012. IEA Wind Task 26: The Past and Future Cost of Wind Energy. National Renewable Energy Laboratory. NREL/TP-6A20-53510. Online at: http://www.nrel.gov/docs/fy12osti/53510.pdf. U.S. Department of Energy (DOE). 2012. Sunshot vision study. Online at http://www1.eere.energy.gov/solar/pdfs/47927.pdf.

[102] Union of Concerned Scientists (UCS). 2013. How renewable electricity standards deliver economic benefits. Cambridge, MA: UCS. Online at www.ucsusa.org/assets/documents/clean_energy/Renewable-Electricity-Standards-Deliver-Economic-Benefits.pdf, accessed on September 15, 2014.

[103] Heeter, J., G. Barbose, L. Bird, S. Weaver, F. Flores-Espino, K. Kuskova-Burns, and R. Wiser. 2014. A survey of state-level cost and benefit estimates of renewable portfolio standards. Golden, CO: National Renewable Energy Laboratory. Online at www.nrel.gov/docs/fy14osti/61042.pdf, accessed on September 19, 2014.

6.2. The EPA's proposed renewable energy targets fall well short of the BSER.

While the EPA draft rule sensibly allows states to use renewable energy as an affordable way to meet their emissions reduction targets, it significantly *underestimates*, in several ways, the potential role of renewable energy in setting state targets as part of the BSER. The Clean Power Plan does not adequately capture renewable energy deployment rates that states are already achieving. The plan also fails to reflect the continued growth and falling costs of renewable energy projected by market experts. Indeed, the EPA's proposal falls short of the national renewable energy generation levels that the U.S. Energy Information Administration (EIA) projects would occur in 2020 under a business-as-usual approach without the CPP, and is only marginally higher than the EIA's projections by 2030 (Figure 6-1).[105]

The EPA's proposed approach for setting state renewable energy targets based on the regional average of state renewable electricity standards in 2020 does not represent the CAA-required "best" system of emission reduction, but more of a "average" or even "below-average" system for many states. The EPA's proposed approach results in the following anomalies:

- In seven states, actual renewable energy generation levels in 2013 exceed the EPA's renewable energy targets in 2030.
- Seventeen of the 29 states with RES policies have lower targets under the EPA approach than what is required under their respective state laws, which is due both to the EPA's averaging of state RES targets in given region and not including RES targets that continue to ramp-up after 2020 in many states.
- The national level of renewable energy generation included in the EPA's state targets is lower than the EIA's business-as-usual projections in 2020, and only marginally greater in 2030 (Figure 6-1).
- The average annual national renewable energy growth rate under the EPA proposal is 0.65 percent of total sales between 2017 and 2030. By contrast, 15 states have already been achieving average annual growth rates of more than 1 percent over the last five years.

---

[104] See pp. 4-30 to 4-32 of the EPA's GHG Abatement Measures Technical Support Document, June 2014.

[105] Energy Information Administration (EIA). 2014. Annual energy outlook 2014. Washington, DC: U.S. Department of Energy. Environmental Protection Agency (EPA). 2014. Technical support document (TSD) for carbon pollution guidelines for existing power plants: Emission guidelines for greenhouse gas emissions from existing stationary sources: Electric utility generating units, EPA-HQ-OAR-2013-0602. Washington, DC: EPA. Online at www2.epa.gov/sites/production/files/2014-06/documents/20140602tsd-ghg-abatement-measures.pdf, accessed on September 15, 2014.

- Although the EPA's methodology aims to have states ramp up their renewable energy level toward reaching their respective regional targets, as many as 25 states do not actually reach the EPA's targets by 2030 because of the low annual growth rates assumed under the agency's proposed approach.
- The EPA does not assume any growth in renewable generation between 2012 and 2017.

The EPA's alternative approach for the renewable energy building block, which is based on technical and economic potential, also underestimates the potential for renewable energy to cut carbon emissions. Nationally, it results in virtually the same renewable energy target as the EPA's proposed approach, though the distribution of renewable energy differs at the state and regional level. (See section 6.4 for other suggested improvements to the EPA's alternative approach.)

Most states have the technological and economic potential to raise their renewable energy use to much higher levels than what the EPA is proposing in the Clean Power Plan. By specifying a larger role for renewable energy in setting state targets, the EPA could ensure that the Clean Power Plan achieves greater overall carbon emissions reductions.

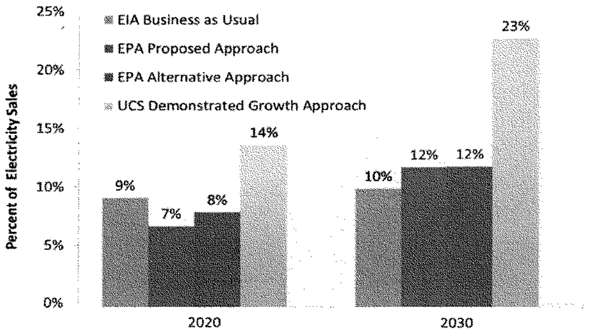


Figure 6-1. The EPA's Renewable Energy Targets Under Its Proposed Clean Power Plan Are Modest.[106] *The renewable energy targets under the EPA's Proposed and Alternative Approaches significantly underestimate the potential of these resources, and result in barely any additional renewable energy beyond what would have occurred under business as usual (i.e., without the proposed rule). By contrast, if the EPA adopted*

---

[106] Environmental Protection Agency (EPA). 2014a. Technical support document (TSD) for carbon pollution guidelines for existing power plants: Emission guidelines for greenhouse gas emissions from existing stationary sources: Electric utility generating units, EPA-HQ-OAR-2013-0602. Washington, DC: EPA. Online at www2.epa.gov/sites/production/files/2014-06/documents/20140602tsd-ghg-abatement-measures.pdf, accessed on September 15, 2014. EIA 2014.

a modified Union of Concerned Scientists proposal for setting state targets—the UCS Demonstrated Growth Approach—grounded in states' actual experience in deploying renewable energy, the renewable energy targets within the plan would nearly double at the national level.

6.3. UCS recommends strengthening the renewable energy building block by adopting the UCS Demonstrated Growth Approach.

UCS recommends modifications to the renewable energy building block that are a logical outgrowth of the EPA's approaches for determining the BSER for the renewable energy building block. Specifically, the EPA should revise its methodology regarding the renewable energy building block's contribution to state targets, by setting renewable energy growth rates that are already being achieved by many states. The EPA should also incorporate full compliance with current state RES laws. In addition, the EPA should use actual generation data from 2013 (or the most recent year available) and include recent and planned renewable energy development between 2013 and 2017. Finally, the EPA should commit to reviewing and strengthening state emissions reduction targets, as well as state renewable energy targets, by 2025, to ensure that the Clean Power Plan is updated to reflect the latest opportunities for cutting CO_2 emissions.[107]

The modified approach that we recommend for setting state renewable energy targets, called the UCS Demonstrated Growth Approach, builds on and improves both of the EPA's approaches by incorporating the following core components:

- Setting a national renewable energy growth rate benchmark based on demonstrated growth in the states from 2009 to 2013;
- Assuming full compliance with current state RES policies, as set by law, that require certain percentages of electricity to come from renewable sources; and
- Accounting for actual and expected renewable energy growth between 2013 and 2017.

As under the EPA approaches, we assume state-level renewable energy targets begin in 2017, the proposed start date for state compliance plans, and ramp up through 2030. To determine each state's 2017 baseline generation levels, we use EIA's actual renewable generation data from 2013[108] (the EPA's approach uses 2012 data) and add projected generation from wind and utility-scale solar projects known to be under construction through 2016.[109]

To calculate state renewable energy targets for 2030, we employ a four-step approach:

---

[107] UCS. 2014. Strengthening the EPA's Clean Power Plan: Increasing renewable energy use will achieve greater emission reductions. Online at http://www.ucsusa.org/renewablesandcleanpowerplan.

[108] Energy Information Administration (EIA). 2014. Electricity data browser. Washington, DC: U.S. Department of Energy. Online at www.eia.gov/electricity/data/browser/, accessed on September 15, 2014.

[109] Wind projects under construction are based on data from the American Wind Energy Association's U.S. Wind Industry Second Quarter 2014 Market Report, online at: http://awea.files.cms-plus.com/FileDownloads/pdfs/2Q2014%20AWEA%20Market%20Report%20Public%20Version%20.pdf. Utility solar PV projects under construction are based on data from SNL Energy's Power Projects Database.

1. First, we use EIA data to calculate each state's average renewable energy growth rate over the five-year period from 2009 to 2013.[110] We find that, on average, states increased their renewable share of electricity sales by 1 percent annually. This growth rate serves as our national benchmark. The 2009–2013 benchmark period accounts for the recent rapid growth in wind and solar technologies; it eases fluctuations in development due to uncertainty around federal tax credit expirations and extensions; and it captures much of the historic development spurred by state RES policies—a key driver of renewables growth. Eleven of the 15 leading states that have achieved growth rates at or above the national benchmark from 2009 to 2013 have also achieved a 1 percent or higher average annual growth rate over a 10-year period from 2004 to 2013.

2. For states below the 1 percent national benchmark, we assume that they gradually ramp up to that rate from 2017 to 2020 in a similar way that the EPA assumes energy efficiency targets would ramp up in Building Block 4. This period serves as an opportunity for states that have not been as active in deploying new renewable energy sources to catch up to the national benchmark. Renewable energy is assumed to grow after 2020 in these states at an annual rate of 1 percent of total sales through 2030.

3. For the 15 leading states among those that have been deploying renewable energy at or above the national benchmark, we increase their respective renewable energy targets from 2017 to 2030 at each state's average annual growth rate during the five-year benchmark period, up to a maximum of 1.5 percent per year. We view this as a reasonable limit that can be sustained over time in states with strong renewable energy potential. This is supported by the fact that seven states have achieved annual average growth rates of 1.5 percent or more over a 10-year period from 2004 to 2013 based on EIA data. Moreover, a 1.5 percent growth rate is consistent with renewable energy targets set by leading RES states.

4. Finally, to account for full compliance with mandatory state RES laws, we assume that states achieve the greater of two measures: the generation projected by our growth rate approach; or the level needed to meet states' respective RES targets for each year from 2017 to 2030, as projected by the Department of Energy's Lawrence Berkeley National Laboratory.[111] To ensure reasonably achievable renewable energy penetration rates during the compliance period, we also cap the total share of renewable generation for any state at 40 percent of total state electricity sales, a level that several studies by grid operators, utilities, and government agencies have shown can be achieved at the state and

---

[110] EIA 2014.

[111] Lawrence Berkeley National Laboratory (LBNL). 2013. Renewables portfolio standards resources. Online at http://emp.lbl.gov/rps, accessed on September 15, 2014.

regional level in this timeframe while maintaining reliability.[112] Only seven states hit this cap prior to 2030.

Key constraints included in our proposal, such as the 1.5 percent annual growth rate cap and the 40 percent cap on the overall target, are reflective of current conditions and thus should be flexible over time. As the EPA undertakes regular reviews of the Clean Power Plan, which should occur at least every eight years as allowed by the Clean Air Act, these constraints could be adjusted upward or eliminated to reflect improvements in renewable energy technologies, grid integration techniques, and falling costs.

6.3.1. The UCS Demonstrated Growth Approach delivers more renewable energy in every region and nearly every state.

The UCS proposal leads to stronger renewable energy targets for states than those proposed in the EPA's draft Clean Power Plan. If all states met these targets, the nation's electricity coming from renewable energy in 2020 would double compared with the EPA's proposal—from 7 percent of total U.S. electricity sales to 14 percent. By 2030, it would result in a 23 percent share of renewable energy, as compared with 12 percent under the current the EPA proposal. All regions of the country, as defined by the EPA in the proposed standard, would see higher renewable energy targets under our improved methodology (Figure 6-2), with higher targets in all but four states (Figure 6-3).

---

[112] For example, see GE Energy Consulting. 2014. Minnesota Renewable Energy Integration and Transmission Study Final Report. Prepared for the Minnesota Department of Commerce. Online at https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7bD607FB96-F80C-49EE-A719-39C411D5D7C3%7d&documentTitle=201411-104466-01. GE Energy Consulting. 2014. PJM Renewable integration study. Schenectady, NY: General Electric International, Inc. Online at http://pjm.com/~/media/committees-groups/task-forces/irtf/postings/pris-executive-summary.ashx, accessed on September 23, 2014. National Renewable Energy Laboratory (NREL). 2012a. Renewable electricity futures study, NREL/TP-6A20-52409. Golden, CO: NREL. Online at www.nrel.gov/analysis/re_futures/, accessed on September 15, 2014. National Renewable Energy Laboratory (NREL). 2012b. Integrating wind and solar energy in the U.S. bulk power system: Lessons from regional integration studies. Golden, CO: NREL. Online at http://variablegen.org/wp-content/uploads/2012/11/55830-LessonsfromEWITSandWWSIS.pdf, accessed on September 19, 2014. Wiser and Bolinger, 2014.

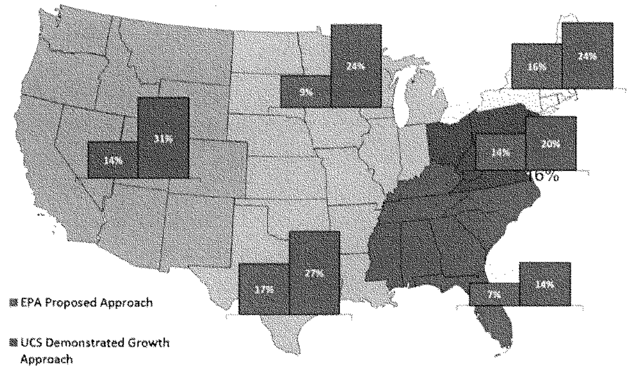


Figure 6-2. Regional Comparison of Renewable Energy Targets, 2030.[113] *The UCS Demonstrated Growth Approach for setting state targets under the Clean Power Plan's renewable energy building block leads to higher targets for 2030 than does the EPA's Proposed Approach, and in every region of the country, as defined by the EPA. In the upper Midwest, West, and Southeast regions, the amount of cost-effective renewable energy generation included in the targets at least double.*

Some of the largest increases in renewable energy targets occur in the leading renewable energy states of the Upper Midwest and the West. Under the EPA's approach, many of the renewable energy targets in these states reflect little, if any, more renewable energy than what they have already achieved. By contrast, our approach encompasses the reasonable expectation that these states will continue to grow at rates similar to what they are currently demonstrating. Further, we assume that full compliance with current state RES policies—a legal requirement, where they exist—should be incorporated into state renewable energy targets. This assumption has the greatest effect among Northeast and Mid-Atlantic States.

---

[113] EPA 2014a. Technical support document (TSD) for carbon pollution guidelines for existing power plants: Emission guidelines for greenhouse gas emissions from existing stationary sources: Electric utility generating units, EPA-HQ-OAR-2013-0602. Washington, DC. Online at www2.epa.gov/sites/production/files/2014-06/documents/20140602tsd-ghgabatement-measures.pdf.

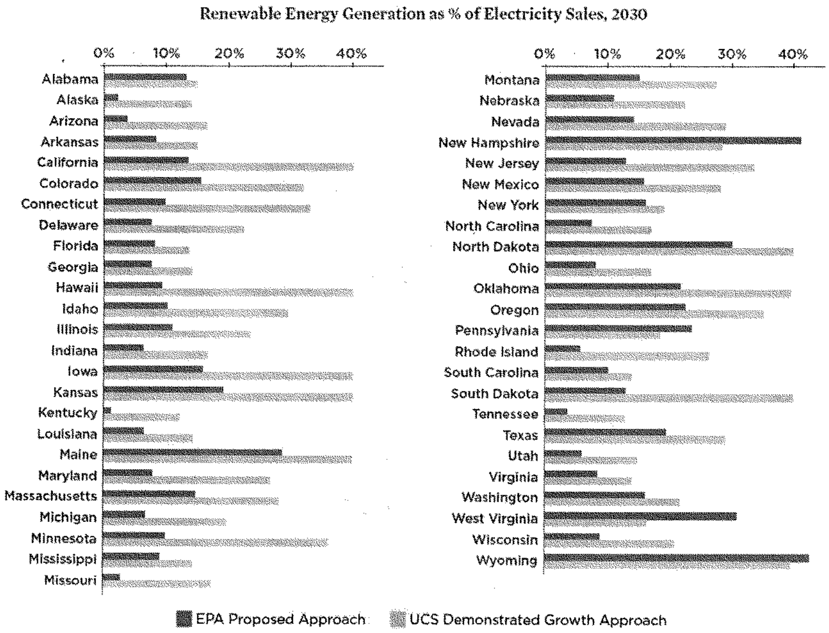


Figure 6-3. Comparison of State Renewable Energy Targets, 2030.[114] *This chart compares the EPA's proposed 2030 renewable energy targets for each state with those of the modified approach recommended by the UCS. As the chart illustrates, the EPA has underestimated the level of renewable energy that can cost-effectively contribute to state emission reduction targets. Nationally, the UCS approach nearly doubles the proportion of renewable energy included in the state targets.*

Table 6-1. Renewables Generation in GWh by State under the UCS Demonstrated Growth Approach.*

State	2020	2025	2030
Alabama	5,711	10,872	16,246
Alaska	322	671	1,036
Arizona	6,762	11,297	16,120
Arkansas	2,927	5,604	8,403
California	92,177	106,506	121,294
Colorado	12,371	17,213	22,360

---

[114] Cleetus, R., S. Clemmer, J. Deyette, S. Mullendore, and J. Richardson. 2014. Strengthening the EPA's Clean Power Plan. Cambridge, MA: Union of Concerned Scientists. Online at http://www.ucsusa.org/sites/default/files/attach/2014/10/Strengthening-the-EPA-Clean-Power-Plan.pdf.

Connecticut	7,329	8,896	10,473
Delaware	1,741	2,377	3,046
Florida	10,688	23,218	36,391
Georgia	7,252	14,703	22,538
Hawaii	2,619	3,149	4,485
Idaho	4,774	6,931	9,224
Illinois	20,146	29,773	37,889
Indiana	8,129	13,821	19,643
Iowa	20,313	21,063	21,558
Kansas	14,893	17,982	18,405
Kentucky	3,403	9,845	16,553
Louisiana	4,950	9,860	14,993
Maine	4,950	5,023	5,033
Maryland	12,758	16,262	19,946
Massachusetts	10,618	13,493	16,387
Michigan	11,573	17,211	22,979
Minnesota	19,041	23,623	28,341
Mississippi	2,871	5,728	8,701
Missouri	6,922	11,842	16,580
Montana	2,577	3,727	4,951
Nebraska	4,138	5,921	7,756
Nevada	7,471	10,232	13,166
New Hampshire	2,161	2,741	3,325
New Jersey	18,562	22,432	26,328
New Mexico	5,564	6,953	8,430
New York	13,860	21,320	28,828
North Carolina	11,621	18,959	26,674
North Dakota	6,870	7,123	7,290
Ohio	12,141	20,328	28,703
Oklahoma	17,906	22,989	28,304
Oregon	11,616	15,574	19,711
Pennsylvania	12,882	20,329	27,825
Rhode Island	1,367	1,777	2,191
South Carolina	4,091	8,557	13,252
South Dakota	3,727	4,735	5,584
Tennessee	3,821	9,444	15,299
Texas	81,548	105,000	129,521
Utah	2,092	3,910	5,842
Virginia	5,932	12,159	18,707
Washington	13,212	18,398	23,818
West Virginia	2,581	4,358	6,226

Wisconsin	8,605	12,389	16,259
Wyoming	5,567	7,101	8,731
National	**555,154**	**773,416**	**995,343**

*For more information on annual targets, see Appendix 2 and the attached spreadsheet.

6.3.2. Achieving higher levels of renewable energy generation under the UCS Demonstrated Growth Approach is technically feasible.

We compared the levels of renewable energy called for under our approach relative to the renewable energy technical potential available at the regional level, using the same data from NREL that the EPA relied on for its alternative approach.[115] In every CPP-region, our approach requires only a small fraction of the vast renewable energy resources that are technically available (Figure 6-4). The technical potential based on the EPA's methodology includes utility and distributed solar photovoltaics, onshore wind, geothermal, and bioenergy.

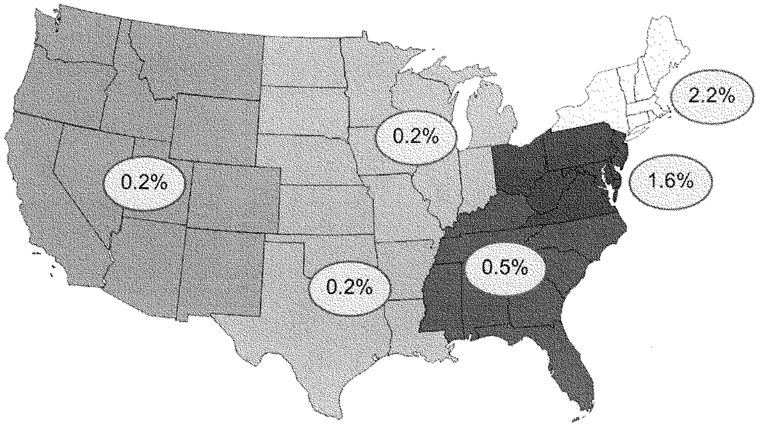


Figure 6-4. Regional Renewable Targets under the UCS Demonstrated Growth Approach as a Percent of Regional Renewable Energy Technical Potential.

Notably, these estimates do not include the tremendous offshore wind potential in the U.S., which the EPA excluded because they claimed that the technology has not been adequately demonstrated to qualify for the BSER. A recent DOE report shows 14 offshore wind projects totaling 4.9 GW are in advanced stages of development in nine states and the Virgin Islands.[116] Given the status of these projects, and the likelihood that states will include them in their state compliance plans, we recommend that the EPA consider including a contribution from offshore wind as a potential BSER option over time.

---

[115] Lopez et al. 2012. U.S. renewable energy technical potentials: A GIS-based analysis. (July 2012). Golden, CO: National Renewable Energy Laboratory. Online at http://www.nrel.gov/gis/re_potential.html.

[116] Wiser and Bolinger, 2014.

6.3.3. The UCS Demonstrated Growth Approach is affordable and will result in greater emission reductions.

Using the National Renewable Energy Laboratory's Regional Energy Deployment System (ReEDS) model, we analyzed the impacts on CO_2 emissions, electricity and natural gas prices, and the electricity generation mix of achieving the state renewable energy targets under the UCS approach compared with business as usual. We believe our analysis is a reasonable approximation of the incremental costs and impacts of increasing renewables under the Clean Power Plan. We did not analyze the full impacts of implementing the entire draft rule, but focused exclusively on the renewable energy building block. Our analysis also included updates to technology cost and performance assumptions that reflected data from recent project installations and mid-range projections from several recent studies as discussed in more detail below and a separate technical appendix.[117]

Under the UCS approach, total CO_2 reductions achieved by the Clean Power Plan could increase from 30 percent below 2005 levels to nearly 40 percent. The ReEDs modeling showed that the additional renewable energy generation would displace mostly natural gas. If more coal were displaced, total emissions reductions could increase above these levels. And of course, improvements in other building blocks within the Clean Power Plan, as well as states' decisions to deploy renewable energy beyond their targets, could further increase the total level of emissions reductions.

Achieving higher renewable energy targets under the Clean Power Plan is also affordable. Diversifying the electricity mix with renewable energy would help reduce the economic risks associated with an overreliance on natural gas.[118] Reducing the demand for natural gas would also lead to lower and more stable natural gas and electricity prices.

Under the UCS proposed approach, national average consumer electricity prices were a maximum of 0.3 percent higher per year than business as usual through 2030 (Figure 6-5). As a result, a typical household (using 600 kWh per month) would see a maximum increase of 18 cents on their monthly electricity bill on average at the national level. Under the UCS proposal, the national average price of natural gas delivered to the electricity sector would be 9 percent lower than business as usual by 2030 (Figure 6-5). At the regional level, average consumer electricity prices would range from a 3.7 percent reduction to a 3.4 percent increase, while power sector natural gas price reductions would range from 8 percent to 17 percent by 2030.

---

[117] See Appendix 1 for documentation on the ReEDs methodology and assumptions.

[118] Bolinger, M. 2013. Revisiting the long-term hedge value of wind power in an era of low natural gas prices. Golden, CO: Lawrence Berkeley National Laboratory. Online at http://emp.lbl.gov/sites/all/files/lbnl-6103e.pdf, accessed on October 2, 2014. Fagan, B., P. Lucklow, D. White, and R. Wilson. 2013. The net benefits of increased wind power in PJM. Cambridge, MA: Synapse Energy Economics, Inc. Mercurio, A. 2013. Natural gas and renewables are complements, not competitors. Washington, DC: Energy Solutions Forum, Inc.

Previous studies have shown that reducing natural gas use in the electricity sector with renewables and energy efficiency can also help reduce consumer natural gas prices and bills for heating, manufacturing, and other uses.[119] For example, a 2007 EIA analysis found that implementing a national RES of 25 percent by 2025 would lower cumulative (from 2009 through 2030) consumer natural gas bills by $17 billion (or 1 percent), more than offsetting the cumulative $15 billion (0.4 percent) increase in consumer electricity bills.[120] These benefits are not captured in our analysis, which uses an energy model that focuses only on the power sector.

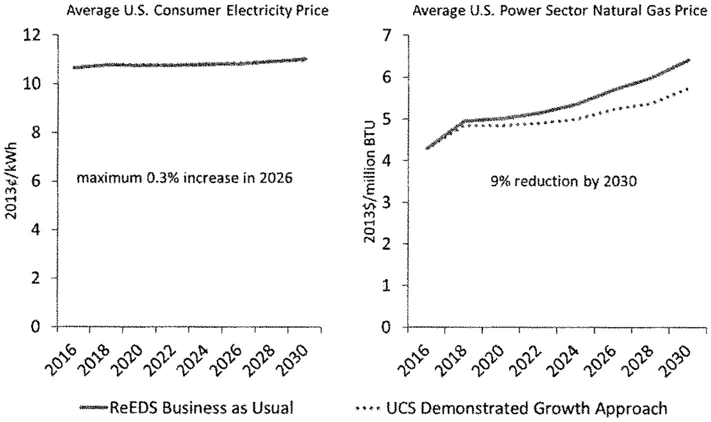


Figure 6-5. UCS Renewable Energy Targets are Affordable.

We also found that the incremental cost of increasing renewables under the UCS proposal was at or below $30/MWh, the range that the EPA identifies as meeting the BSER cost criteria under the Clean Power Plan.[121] These results assume national trading of renewable energy credits

---

[119] Cleetus, R., S. Clemmer, and D. Friedman. 2009. Climate 2030: A national blueprint for a clean energy economy. Cambridge, MA: Union of Concerned Scientists. Online at www.ucsusa.org/global_warming/solutions/big_picture_solutions/climate-2030-blueprint.html, accessed on September 19, 2014. Union of Concerned Scientists (UCS). 2009. Clean power, green jobs. Cambridge, MA: UCS. Online at www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_energy/Clean-Power-Green-Jobs-25-RES.pdf, accessed on October 2, 2014. EIA. 2007. Energy and economic impacts of implementing both a 25-percent Renewable Portfolio Standard and a 25-percent Renewable Fuel Standard by 2025. Washington, DC: US Department of Energy. Online at http://www.eia.gov/analysis/requests/2007/eeim/pdf/sroiaf(2007)05.pdf. Wiser R., M. Bolinger and M. Clair. 2005. Easing the natural gas crisis: Reducing natural gas prices through increased deployment of renewable energy and energy efficiency. Berkeley, CA: Ernest Orlando Lawrence Berkeley National Laboratory.

[120] See p. 17 of: EIA. 2007. Energy and economic impacts of implementing both a 25-percent Renewable Portfolio Standard and a 25-percent Renewable Fuel Standard by 2025. Washington, DC: US Department of Energy. Online at http://www.eia.gov/analysis/requests/2007/eeim/pdf/sroiaf(2007)05.pdf.

[121] Environmental Protection Agency (EPA). 2014b. Clean Power Plan proposed rule: Alternative renewable energy approach: Technical support document. Washington, DC: EPA. Online at www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-alternative-renewable-energy-approach, accessed on September 15, 2014. Environmental Protection Agency (EPA). 2014c. Carbon pollution emission guidelines for existing stationary sources: Electric utility generating units, 79 FR 34829, pp. 34829–34958. Online at https://federalregister.gov/a/2014-13726, accessed on September 15, 2014.

(RECs). RECs represent the energy and environmental attributes of renewable electricity and serve as the basis for documenting ownership rights and trading transactions across the United States in both RES and voluntary markets. RECs and existing REC tracking systems would also be effective in accounting for the contribution of renewable energy within the Clean Power Plan framework, as discussed in more detail section 6.5.

If there are any limits placed on trading between regions, experience with renewable energy markets suggests that REC prices would likely be higher in some regions and lower in other regions of the country.[122] Furthermore, increasing renewable energy, in combination with other technologies and measures to cut carbon emissions—such as greater investments in energy efficiency or more fuel switching from coal to natural gas—would lead to different impacts on energy prices and consumer bills.

Our modeling results also show a diverse mix of renewable energy resources being deployed, including significant increases in onshore wind and solar energy and more modest contributions from geothermal and biomass (Figure 6-6). We should note that our methodology is technology neutral and there could be significant regional variation in the actual renewable energy resources deployed. Of course, state policies that are implemented to help achieve compliance with the rule could also impact what renewable resources get developed. For example, this could result in more offshore wind development on the east coast.

---

[122] Heeter, J., G. Barbose, L. Bird, S. Weaver, F. Flores-Espino, K. Kuskova-Burns, and R. Wiser. 2014. A survey of state-level cost and benefit estimates of renewable portfolio standards. Golden, CO: National Renewable Energy Laboratory. Online at www.nrel.gov/docs/fy14osti/61042.pdf, accessed on September 19, 2014.

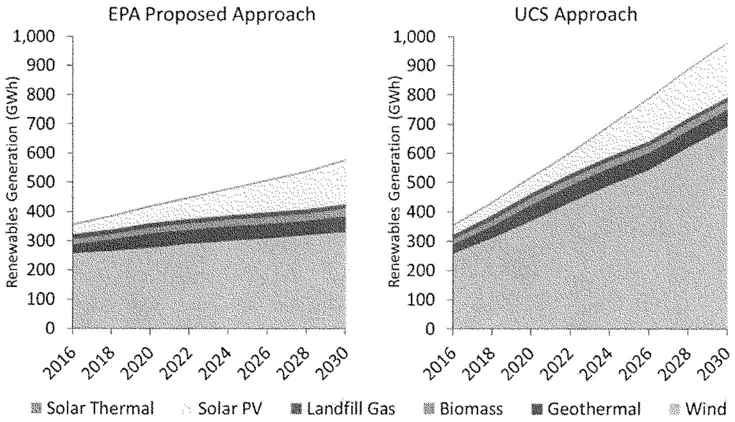


Figure 6-6. U.S. Renewable Generation Mix Under the EPA Proposed Approach vs. the UCS Demonstrated Growth Approach, Based on UCS ReEDs Modeling.

6.3.4. The UCS Demonstrated Growth Approach is robust across a range of assumptions.

We analyzed sensitivities related to key parameters in our approach and found that it is robust to these changes. The sensitivities we analyzed included:

- Setting all states growth rate at 1 percent, instead of allowing leading states to grow at a higher rate up to 1.5 percent;
- Capping the share of electricity sales from renewable energy at 33 percent, instead of 40 percent;
- Removing the requirement that states would need to increase renewable energy by at least the level needed to meet states' respective RES targets for each year from 2017 to 2030; instead only the growth rate of 1 to 1.5 percent would apply;
- Removing the 40 percent cap on the share of electricity sales from renewable energy;
- Removing the 1.5 percent cap on a state's annual renewable energy growth rate and assuming it will continue to increase at the average annual growth rate from 2009-2013;
- Removing both the 40 percent cap and the 1.5 percent cap.

Compared with our core approach which delivered 23 percent renewable energy by 2030, these sensitivities resulted in a range of 20.3 percent to 25.3 percent (Figure 6-7).

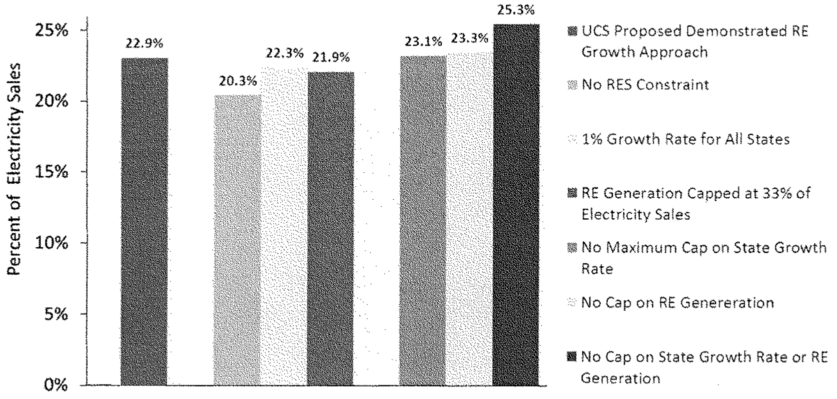


Figure 6-7. UCS Demonstrated Growth Approach Sensitivity Analysis. *Note: The underlying data are included in the UCS State Level Data spreadsheet uploaded as an attachment to these comments.*

6.4. UCS recommends that the EPA, if it adopts its Alternative Approach, eliminate the technical potential benchmarks, rely primarily on economic potential to set state and regional targets, use updated renewable energy cost and performance assumptions, and reflect regional differences and existing state commitments.

While the UCS Demonstrated Growth Approach is our preferred approach for strengthening the renewable energy building block, we also offer two other options that are focused on improving the EPA's Alternative Approach. Under this approach, the EPA set state targets based on the lesser of an assessment of the economic/market potential as projected by their own Integrated Planning Model (IPM) modeling, or a national benchmark rate for renewables deployment informed by data on existing renewable energy generation and resource technical potential.[123] This approach significantly underestimates the potential for renewable energy to cut carbon emissions. Nationally, it results in virtually the same renewable energy target as the EPA's Proposed Approach (Figure 6-1), though the distribution of renewable energy differs at the state and regional level.

The first option for strengthening the EPA's Alternative Approach relies primarily on the economic potential of renewable energy to set state and regional targets, but recommends several improvements to the EPA's methodology and modeling assumptions to develop a more realistic estimate of economic potential. The second, less preferred, option incorporates regional differences in renewable energy market penetration rates. Similar to the UCS Demonstrated

---

[123] Environmental Protection Agency (EPA). 2014. Clean Power Plan Proposed Rule: Alternative renewable energy approach: Technical support document. Washington, DC: EPA. Online at www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-alternative-renewable-energy-approach, accessed on September 15, 2014.

Growth Approach, both of these approaches assume full compliance with existing state RESs laws as a floor, which is consistent with the EPA's "no backsliding" policy principle.[124]

6.4.1. The EPA should eliminate technical potential benchmarks and rely primarily on economic potential to set state and regional renewable energy targets.

We have several concerns with the EPA's use of technical potential benchmarks that are based on the recent deployment of specific renewable energy technologies in leading states as a fraction of the estimated technical potential for each technology. This approach effectively imposes an arbitrary cap on the share of the renewable energy potential that can be developed in a given state or region. The technical potential benchmark rates captures a moment in time, and do not incorporate projected cost reductions and improved performance for many technologies that would likely result in even faster growth. Using 2012 data on renewable generation in the top states to define the benchmark deployment rate in 2030 does not capture the projected growth in renewable energy between those years that would result in significantly higher state and regional renewable energy targets.

In fact, more recent data show much faster growth than the EPA assumed in their technical potential benchmark cap. The American Wind Energy Association (AWEA) and the Solar Energy Industries Association (SEIA) cite several examples in their comments showing how the EPA's approach underestimates the recent and projected growth of wind and solar. The EPA even acknowledges in the technical support document that many states have already exceeded their benchmark rate and some of the limitations of using technical potential data in general.[125] This provides further evidence that their approach is overly conservative.

Some of the assumptions the EPA used for the technical potential estimates based on a 2012 NREL report are also outdated.[126] For example, NREL's capacity factors (CF) and land area assumptions for wind are low and do not reflect the recent and projected improvements in wind technology, as discussed in more detail below.[127] While NREL's estimates demonstrate the enormous technical potential for wind, solar and other technologies to produce significantly more electricity than the U.S. currently needs, they do not reflect important cost considerations of developing different sites or from increasing the penetration of renewables.

Using a technical potential benchmark rate is also redundant with the EPA's IPM modeling of economic potential. The IPM model includes assumptions on renewable resource availability, the cost and performance of different renewable energy technologies, and transmission and integration costs that may occur as the penetration of renewable energy increases over time. It also takes into account changes in the cost and performance of conventional technologies and the impacts of state and federal policies, which can impact the costs and penetration of renewable energy. With some updates and improvements to the EPA's IPM modeling assumptions for renewables and other technologies suggested below and in the attached UCS ReEDs methodology and assumptions document, we believe the EPA can eliminate the technical potential benchmark caps and rely entirely on modeling results from IPM and other energy models to set state or regional renewable energy targets.

---

[124] Proposed Rule, 34917.
[125] For example, see p. 2 of the EPA's Alternative RE Approach Technical Support Document.
[126] Lopez et al., 2012.
[127] Wiser and Bolinger, 2014; and Roberts, J.O. New National Wind Potential Estimates for Modern and Near-Future Turbine Technologies. National Renewable Energy Laboratory. Poster presentation at the 2014 Wind Project Siting Seminar, January 29-30, 2014, New Orleans, LA. NREL/PO-5000-60979.

6.4.1.1. The EPA should use more up-to-date cost and performance assumptions for renewable energy technologies in its economic modeling

Many of the EPA's cost, performance, and resource availability assumptions used in their IPM modeling are pessimistic and outdated. They are based primarily on assumptions from EIA's Annual Energy Outlook 2013 that don't reflect recent improvements in wind and solar technologies. They should be updated to reflect new NREL resource assessments, more recent data from actual projects, and credible studies projecting continued cost reductions and technology improvements through 2030. These studies and data sources are discussed in more detail in the following sections for each renewable energy technology.

We also recommend that the EPA request from NREL updated renewable resource assessments and cost and performance assumptions that will be included in the forthcoming DOE Wind Vision study. This report and the assumptions developed for the modeling went through an extensive peer-review process involving more than 300 energy experts, representing grid operators, the wind industry, science-based organizations, academia, governmental agencies, and environmental organizations. UCS served on the Senior Peer Review Advisory Group and several stakeholder task forces for this study.

While the full Wind Vision report isn't scheduled to be released until early next year, DOE issued an early release of the Executive Summary and Roadmap chapter on November 19, 2014.[128] The early release shows that increasing wind power from 4.5 percent of U.S. electricity use in 2013 to 10 percent in 2020, 20 percent in 2030, and 35 percent in 2050 is technically and economically feasible. Achieving these targets would require less than 5 percent of the country's available wind resource potential and would result in a less than 1 percent (0.1 cents/kWh) increase in electricity costs by 2030, and a 2 percent *reduction* in electricity costs by 2050. In addition, the study found that achieving the Wind Vision (compared to a baseline scenario) would result in cumulative (2013-2050) savings of:

- $400 billion in avoided global climate change damages from reducing power plant carbon emissions by 12.3 gigatons of CO_2-equivalent (a 14 percent reduction);

---

[128] U.S. Department of Energy (DOE). 2014. Wind Vision: A New Era for Wind Power in the United States (Industry Preview). DOE/GO-102014-4557. Online at http://energy.gov/eere/wind/downloads/draft-industry-preview-wind-vision-brochure.

- $108 billion in avoided health and economic damages from reducing particulate matter, nitrous oxide, and sulfur dioxide emissions; and
- $280 billion in lower consumer natural gas bills and total electric system costs that are 20 percent less sensitive to natural gas price fluctuations.[129]

Onshore wind. Improvements in low wind speed turbines are also opening new areas in the U.S. for potential development that were previously not considered to be economically viable. A recent GIS analysis by NREL shows that these improvements would increase the deployable area for potential onshore wind development in the U.S. by more than 50 percent at sites with gross CFs greater than 30 percent.[130] This represents an additional 3,907 GW of installed wind capacity potential compared to previous estimates. For example, they show that the Southeast has the potential to develop 134 GW onshore wind capacity at sites with gross CFs above 40 percent (net CF of ~34 percent) at hub heights of 140 meters. NREL also found that raising the hub height from just 96 meters to 110 meters would increase the windy land area above a 30 percent gross CF by 320,000 km^2, representing 1,000 GW of additional wind capacity mostly in the Eastern and Southeastern U.S.

We recommend updating the IPM cost and performance assumptions for onshore wind using recent data on actual projects from DOE's 2013 Wind Technologies Market report.[131] The EPA's modeling assumes capital costs of $2,258/kW (in 2011$) for wind projects installed in 2016, declining to $2,039/kW in 2030.[132] The EPA's 2016 costs are more reflective of average installed costs from actual wind projects installed in 2009 and 2010, and are nearly 40 percent higher than capacity-weighted average installed costs of $1,630/kW (in 2013$) for actual U.S. projects installed in 2013.[133] However, the sample size of projects installed in 2013 was limited and heavily weighted by low cost projects installed in the interior region of the country. A larger sample of 16 projects representing 2,000 MW that are under construction and anticipated to be completed in 2014 have average installed costs of approximately $1,750/kW. However, these projects are also weighted toward lower cost projects in the interior region. Thus, we would recommend using national average capital costs of $1,940/kW (in 2013$) for current projects based on average costs from a much larger sample of recent projects installed in 2012 and 2013.[134]

---

[129] Cumulative figures from the study are calculated based on the present value of costs and savings between 2013 and 2050, using a 3 percent discount rate.

[130] Roberts, 2014. Also see Figure 6 and Figure 8 in Cotrell, J., T. Stehly, J. Johnson, J.O. Roberts, Z. Parker, G. Scott, and D. Heimiller. 2014. Analysis of transportation and logistical challenges affecting the deployment of larger wind turbines: Summary of results. National Renewable Energy Laboratory. Technical Report: NREL/TP-5000-61063.

[131] Wiser and Bolinger, 2014.

[132] See Chapter 4, Table 4-16, on p. 29 of the EPA IPM model documentation.

[133] Wiser and Bolinger, 2014. See Figure 39, on p. 49.

[134] These regional differences are illustrated in Figure 42 of the DOE report (Wiser and Bolinger 2014). Because the sample size for the Southeast only reflects one project, we would suggest using assuming national average installed costs for that region.

We recommend basing capacity factors for new wind projects on data from recent projects and studies that reflect recent technology advances, as described in the DOE report.[135] We also recommend basing future increases in capacity factors and reductions in capital costs on the DOE Wind Vision study, which projects the average levelized cost of electricity (LCOE) from onshore wind projects to decline 24 percent by 2020, 33 percent by 2030 and 37 percent by 2050.[136] These are mid-range projections based primarily on a recent NREL literature review of 13 independent studies and 18 scenarios.[137] Based on these assumptions, the ReEDs model projects that 110 GW of onshore wind capacity would be installed in the U.S. by 2020, and 200 GW by 2030, to meet the Wind Vision targets.

Offshore wind. The EPA excluded offshore wind arguing that the technology has not been adequately demonstrated in the U.S. and little cost information is available to qualify for the BSER. However, a recent DOE report by Navigant Consulting[138] shows 14 offshore wind projects totaling 4,900 MW are in advanced stages of development in nine states (Delaware, Massachusetts, Maine, New Jersey, Ohio, Oregon, Rhode Island, Texas, Virginia) and the Virgin Islands. According to the report, this includes projects that "have a signed power purchase agreement (PPA), have received approval for an interim limited lease or a commercial lease in state or federal waters, and/or have conducted baseline or geophysical studies at the proposed site with a meteorological tower erected and collecting data, boreholes drilled, or geological and geophysical data acquisition systems in place."[139] In addition, considerable information on the costs of developing offshore wind is available from recent projects in developed in Europe and proposed in the U.S.[140]

We recommend using the DOE Wind Vision cost and performance assumptions for offshore wind, and the sources listed in the technical appendix of the UCS ReEDs modeling. The DOE Wind Vision report assumes that the LCOE from offshore wind projects will decline 22 percent by 2020, 43 percent by 2030, and 51 percent by 2050. The report also assumes that 3 GW of offshore wind capacity will be installed in the U.S. by 2020 and 20 GW by 2030. As discussed above, when combined with the projected deployment of onshore wind, these levels of offshore wind can be achieved at a modest increase in electricity costs of less than 1 percent by 2030, while saving hundreds of billions in avoided climate, health and economic damages and lower natural gas bills.

---

[135] See Chapter 5 in the DOE report starting on p. 38. In particular, see the trend over time of increasing capacity factors in different wind regimes shown in Figure 35, and the regional variation in capacity factors for projects installed in 2012 in Figure 36.

[136] U.S. Department of Energy (DOE). 2014. Wind Vision: A New Era for Wind Power in the United States (Industry Preview). DOE/GO-102014-4557. Online at http://energy.gov/eere/wind/downloads/draft-industry-preview-wind-vision-brochure.

[137] Lantz, E., R. Wiser and M. Hand. 2012. IEA Wind Task 26: The Past and Future Cost of Wind Energy. National Renewable Energy Laboratory. NREL/TP-6A20-53510. Online at http://www.nrel.gov/docs/fy12osti/53510.pdf.

[138] U.S. Department of Energy. 2014. Offshore Wind Market and Economic Analysis: 2014 Annual Market Assessment. Prepared by Navigant Consulting, DE-EE0005360 (September 8, 2014). Online at http://energy.gov/sites/prod/files/2014/09/f18/2014 percent20Navigant percent20Offshore percent20Wind percent20Market percent20 percent26 percent20Economic percent20Analysis.pdf.

[139] Wiser and Bolinger, 2014.

[140] Schwartz, M., D. Heimiller, S. Haymes, and W. Musial. 2010. Assessment of offshore wind energy resources for the United States. Golden, CO: National Renewable Energy Laboratory. NREL/TP-500-45889.

Solar. The EPA's IPM modeling assumes overnight capital costs for utility-scale PV of $\$3{,}364/\text{kW}_{ac}$ (2011\$) in 2016, declining to $\$2{,}859/\text{kW}_{ac}$ in 2030. These costs are 32-55 percent higher than recent projects reported in SEIA's *Solar Market Insight Q2 2014 Report*, which shows national average installed system prices of $\$1{,}810/\text{kW}_{dc}$ ($\sim\$2{,}170/\text{kW}_{ac}$)—representing a 14 percent drop in costs from last year and 61 percent from 2010 levels.[141] We recommend using SEIA and the Lawrence Berkeley National Laboratory (LBNL)[142] data on the costs of recent projects and projections of future costs for utility and distributed PV and concentrating solar power (CSP) from the 2012 DOE Sunshot Study's 62.5 percent cost reduction scenario through 2020 and the 75 percent cost reduction scenario through 2040, as reasonable mid-range projections.[143]

We also recommend including distributed solar PV generation in the baseline renewable generation based on data from EIA forms 860, 861, and 826, as recommended in SEIA's technical comments. We also agree with SEIA's comments that distributed solar PV should be considered in the BSER. With cumulative U.S. capacity more than doubling over the past two years to 7,220 MW through the first half of 2014, distributed solar PV has clearly been adequately demonstrated, can be implemented at reasonable costs, and has the potential to significantly reduce carbon emissions. Since the IPM model does not include distributed PV, we would recommend using projections from NREL's SolarDS model based on the Sunshot study's 62.5 percent cost reduction scenario through 2020 and the 75 percent cost reduction scenario through 2040. SEIA also provides several credible options for tracking and verifying generation and emission reductions from distributed solar that the EPA should adopt.

Biopower. The EPA should include updated assumptions for biopower in its assessment of meeting state renewable energy generation targets. New stand-alone biopower projects, efficient combined heat and power (CHP) plants, and biomass co-firing in existing coal plants all have the technical and economic potential to provide additional low carbon electricity, when combined with strong sustainability criteria. However, if not managed carefully, biomass for energy can be harvested at unsustainable rates, damage ecosystems, produce harmful air pollution, consume large amounts of water, and produce net greenhouse emissions. Most scientists believe there is a wide range of biomass resources that can be produced sustainably and with minimal harm, and cut overall carbon emissions, while reducing the overall impacts and risks of our current energy system.[144] Implementing proper policy is essential to securing the benefits of biomass and avoiding its risks.

---

[141] Solar Energy Industries Association (SEIA). 2014. U.S. Solar Market Insight Q2 2014 Report. Online at www.seia.org/smi.

[142] Barbose, G., N. Darghouth, S. Weaver, and R. Wiser. 2013. Tracking the sun VI: An historical summary of the installed price of photovoltaics in the United States from 1998 to 2012. LBNL-6350E. Berkeley, CA: Lawrence Berkeley National Laboratory. Online at http://emp.lbl.gov/sites/all/files/lbnl-6350e.pdf, accessed on September 15, 2014.

[143] U.S. Department of Energy (DOE). 2012. Sunshot vision study. Online at http://www1.eere.energy.gov/solar/pdfs/47927.pdf.

To capture the benefits of beneficial biomass and avoid the risks of harmful biomass, federal and state policies should distinguish between beneficial and harmful biomass resources by including a definition of eligible biomass resources. This definition should make beneficial biomass resources eligible, exclude harmful biomass resources and practices, and include practical, reasonable sustainability standards to ensure that harvests of biomass do not degrade soils, wildlife habitat, biodiversity and water quality.

Taking these factors into account, a 2012 UCS analysis of data from DOE's Updated Billion Ton study found that biomass resources totaling nearly 680 million tons could be made available, in a sustainable manner, each year within the United States by 2030.[145] This is enough biomass to produce approximately 730 billion kilowatt-hours or 18 percent of U.S. electricity generation in 2013. The study showed that biomass resources are readily available in large parts of the country, with the most potential in the southern Plains, Southeast, Midwest, and California. The vast majority (82 percent) of this potential is from energy crops (primarily switchgrass) and agricultural residues, while the potential from biomass wastes (15 percent) such as urban and mill residues, and forest residues (3 percent) is relatively small. In addition, we completely excluded forest biomass from whole trees, thinnings, clearings, and pulp-wood harvesting due to sustainability concerns

As shown in Figure 6-6, our ReEDs modeling projects biopower to make a fairly small contribution to achieving the renewable targets from our Demonstrated Growth Approach at the national level. However, other studies by NREL,[146] EIA,[147] and UCS,[148] have shown that biopower could make a more meaningful contribution, particularly in some parts of the country that have strong potential, such as the Southeast and Midwest. For example, NREL's 2012 *Renewable Electricity Futures* study found that biopower could provide nearly 6 percent of U.S.

---

[144] UCS supports the use of strong sustainability criteria for biomass. For example, in 2011, UCS and eleven other national groups signed on to the following *Principles for Sustainable Biomass*, online at http://www.cleanenergy.org/wp-content/uploads/Principles-for-Sustainable-Biomass-FINAL.pdf. Also see UCS. 2009. A Balanced Definition of Renewable Biomass. Online at http://www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_energy/balanced-biomass-definition.pdf. UCS's Bioenergy Principles. Online at http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/how-biomass-energy-works.html#c2

[145] Union of Concerned Scientists (UCS). 2012. The promise of biomass: clean power and fuel—if handled right. Online at http://www.ucsusa.org/assets/documents/clean_vehicles/Biomass-Resource-Assessment.pdf. Oak Ridge National Laboratory—U.S. Department of Energy (ORNL). 2011. U.S. billion-ton update: Biomass supply for a bioenergy and bioproducts industry. ORNL/TM-2011/224. Oak Ridge, TN. Online at http://www1.eere.energy.gov/bioenergy/pdfs/billion_ton_update.pdf.

[146] National Renewable Energy Laboratory (NREL). 2012a. Renewable electricity futures study, NREL/TP-6A20-52409. Golden, CO: NREL. Online at www.nrel.gov/analysis/re_futures/, accessed on September 15, 2014.

[147] Energy Information Administration (EIA). 2014. *Annual Energy Outlook 2014*. Washington, DC: U.S. Department of Energy. Online at http://www.eia.gov/forecasts/aeo/pdf/0383(2014).pdf

[148] Cleetus, R., S. Clemmer, J. Deyette, and S. Sattler. 2014. Climate Game Changer: How a carbon standard can cut power plant emissions in half by 2030. Cambridge, MA: Union of Concerned Scientists. Online at http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/Carbon-Standards-Analysis-Union-of-Concerned-Scientists.pdf.

generation by 2030 and 15 percent by 2050, making a meaningful contribution to achieving overall renewable electricity targets of 80 percent by 2050.[149]

The EPA's ongoing work on the *Framework for Assessing Biogenic Carbon Dioxide for Stationary Sources* is critical to understanding the role that sustainable biomass can play in reducing GHG emissions, and establishing the safeguards necessary to ensure robust accounting of lifecycle emissions and other impacts from the use of biomass.[150] UCS will continue to review and assess the findings in the latest report as it undergoes review by the Science Advisory Board.[151]

Geothermal and Hydro. The potential for new geothermal and hydropower development is very site specific. We recommend using updated supply curves for new geothermal and hydropower from NREL's ReEDs model that reflect site specific costs and resource potential.

6.4.1.2. The EPA should eliminate the cap on variable wind and solar used in the IPM modeling, or use a cap based on recent studies by utilities, grid operators, and government agencies.

We agree with AWEA's comment that the EPA should not impose a firm cap on the percentage of variable (wind and solar) renewable energy that can be deployed in a state or region, but rather should economically model the cost of curtailment that could occur at extremely high renewable energy penetrations. However, if the EPA continues to impose a cap, it should rely on the results of recent renewable integration studies done by utilities, grid operators, NREL and other government agencies. These studies have found that penetrations of variable renewable energy resources of 40-50 percent are achievable on a state and regional level, with modest integration costs.

For example, NREL's *Renewable Energy Futures* study examined a case in which wind and solar provide nearly 50 percent of total U.S. electricity generation by 2050.[152] The Nebraska Power Association wind integration study found minimal integration costs and no reliability concerns associated with wind providing 40 percent of electricity in the Southwest Power Pool.[153] The Minnesota Department of Commerce just released a comprehensive study that found no challenges to integrating 40 percent wind and solar energy in Minnesota, including a detailed examination of power system dynamics and other essential reliability services. The study also found no challenges associated with accommodating the variability with wind and solar providing 50 percent of electricity in the state, though due to time constraints the study did not include a full analysis of power system dynamics in that case.[154] NREL's analysis of over 30 percent renewable energy penetrations in the Eastern and Western U.S. by 2030 also found no reliability problems or economic barriers.[155] If the EPA does decide to impose such a cap, non-variable renewables, such as biomass and geothermal, should not count towards such a cap.

---

[149] NREL, 2012a.

[150] EPA. 2014. Framework for Assessing Biogenic CO_2 Emissions from Stationary Sources. United States Environmental Protection Agency, Office of Air and Radiation Office of Atmospheric Programs, Climate Change Division. Washington, DC. Online at http://www.epa.gov/climatechange/ghgemissions/biogenic-emissions.html

[151] http://www.epa.gov/climatechange/downloads/Biogenic-CO2-Emissions-Memo-111914.pdf

[152] NREL, 2012a.,.

[153] http://www.nepower.org/Wind_Study/final_report.pdf.

6.4.1.3. The EPA should drop or modify the short-term capital cost adders that raise the cost of renewables by an unreasonable amount.

The EPA also applies unrealistically high short-term capital cost adders to renewable and conventional generation technologies if the new capacity developed in a specific year exceeds a certain upper bound. The adder is designed to reflect potential short-term cost increases due to competition for equipment and labor, based on EIA assumptions. For example, in 2016, the EPA assumes wind capital costs will increase by $694/kW after 11,618 MW are developed, and utility solar PV increases by $1,025/kW after only 286 MW are deployed, over a two-year period.

We do not believe these assumptions are supported by actual experience or credible peer-reviewed research. For example, the capacity-weighted average capital cost of wind projects installed in the U.S. dropped by 10 percent in 2012, despite installing a record 13,131 MW that year.[156] Similarly, the costs of solar PV have continued to drop over the past several years as new records are set nearly every year in the U.S., including adding over 2,000 MW of utility-scale PV just last year.[157] With more than 15,600 MW of wind projects and 3,160 MW of utility scale solar PV currently under construction between 2014 and 2016 in the U.S.[158], the EPA's assumed upper bounds for these technologies will likely be exceeded in the next few years, resulting in a significant overestimate of the cost of developing renewables in IPM. We recommend replacing IPM's short-term capital cost adders for renewables based on detailed regional renewable resource supply curve data from NREL's ReEDs model that account for transmission, integration, and other costs as the penetration of renewables increase.

6.4.1.4. The EPA should re-run the IPM modeling using updated assumptions for renewable technologies and consider different modeling approaches from other sources that use similar assumptions.

The EPA modeled the economic potential of renewables at the state level in IPM by reducing the costs of new renewable builds by $30 per MWh, which is a proxy for the estimated cost of the proposed approach (up to $40 per metric ton CO_2). The EPA should re-run this scenario in the IPM model using more up-to-date assumptions for renewable energy technologies described above to develop new state and regional renewable energy targets. The EPA's modeling should also reflect existing state and federal renewable policies, including but not limited to state RESs, consistent with the EPA's "no backsliding" policy principle.[159]

---

[154] https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId=%7bD607FB96-F80C-49EE-A719-39C411D5D7C3%7d&documentTitle=201411-104466-01.

[155] http://www.nrel.gov/docs/fy11osti/47078.pdf, http://www.nrel.gov/electricity/transmission/western_wind.html

[156] Wiser and Bolinger, 2014.

[157] SEIA 2014.

[158] Wind projects under construction are based on data from the American Wind Energy Association's U.S. Wind Industry Second Quarter 2014 Market Report, online at http://awea.files.cms-plus.com/FileDownloads/pdfs/2Q2014%20AWEA%20Market%20Report%20Public%20Version%20.pdf. Utility solar PV projects under construction are based on data from SNL Energy's Power Projects Database.

We support the Natural Resource Defense Council's (NRDC) analysis of the EPA's Alternative Approach using an updated version of the IPM model, which addresses many of these concerns. NRDC's analysis uses updated cost and performance assumptions for renewables that are similar to the assumptions used in the DOE Wind Vision study and the UCS ReEDs modeling described above. They also ran the scenario in the same way as the EPA, by applying a $30/MWh cost reduction to new renewable builds. Under this scenario, renewable generation increased to 973 TWh by 2030 (including 94 TWh of distributed solar) at the national level. This is similar to the levels of renewable generation achieved under the UCS Demonstrated Growth Approach (995 TWh), but considerably more than the EPA Alternative Approach (527 TWh) and the EPA's IPM modeling (358 TWh). However, the state and regional distribution of renewables varies considerably across the different approaches.

It is also worth noting that the EPA's IPM modeling of meeting the state emission rate reduction targets completed for the regulatory impact analysis (RIA) resulted in a much lower level of renewables than either their Proposed Approach or Alternative Approach. At the national level, total non-hydro renewable generation reached 356 terawatt-hours (TWh) by 2030 in the RIA, which is 32 percent lower than the EPA's renewable energy targets under the Proposed and Alternative Approaches (525 TWh by 2030), only 2 percent above the EPA's base case, and nearly 20 percent lower than EIA's business-as-usual projection (Figure 6-8). In other words, the EPA's results imply that the Clean Power Plan would take us backwards and result in less renewable generation than we would expect to see under existing state and federal policies without the CPP. Even the EPA's base case greatly underestimates the potential contribution from renewables compared to EIA's BAU projections, despite using EIA's assumptions for most technologies.

---

[159] Proposed Rule, 34917.

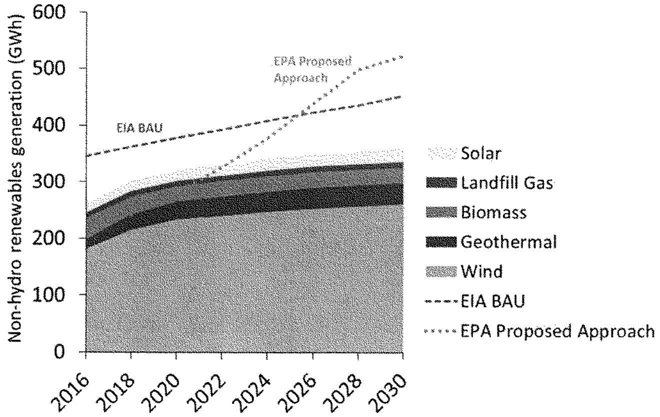


Figure 6-8. The EPA's IPM Modeling Does Not Achieve the Renewable Energy Targets from the EPA's Proposed Approach or EIA's Business As Usual Projection. *The generation from different renewable energy technologies included in the stacked bars is based on the results of the EPA's IPM modeling completed for the Regulatory Impact Analysis (RIA). The overall level of non-hydro renewable generation from the EPA's Proposed Approach is taken directly from the EPA's building block spreadsheet that is used to calculate state emission rate reduction targets, except 2029 levels are shown in 2030, as the EPA did not report values for 2030. EIA's BAU is based on projections from Annual Energy Outlook 2014.*

While the EPA's pessimistic results for renewables are due in large part to their use of outdated and pessimistic assumptions for renewables described above, they are also due to how the EPA modeled the scenarios in the RIA and the EPA's modest state emission reduction targets. The EPA modeled these scenarios by hard-wiring the estimated demand reductions from the energy efficiency building block (because energy efficiency is not explicitly represented in the model) and then letting the model decide what technologies to deploy to achieve the remaining emission reductions in the most cost-effective way.[160] Because the vast majority of the CO_2 reductions appear to have come from energy efficiency, the model only needed to achieve a fairly modest amount of additional CO_2 reductions, which came primarily from fuel switching to existing new natural gas combined cycle plants (NGCC) and from new NGCC plants added by 2020. Combined, efficiency and NGCC generation primarily displaced existing coal and some older oil and gas steam generation.[161] However, the level of efficiency savings by 2030 was high enough to displace generation from new NGCC plants that were built under the base case.

While this approach may have achieved the EPA's state emission reduction targets, it does not capture the economic potential for deploying renewables at higher levels to cost-effectively achieve even deeper emission reductions. The EPA modeling for the Alternative RE Approach clearly demonstrates that it is cost-effective to deploy more renewables even using pessimistic assumptions, while UCS and NRDC modeling of the renewable energy building block shows we can go much further using more reasonable updated assumptions. This makes a strong case for why the EPA's state emission reduction targets should be strengthened. In addition to updating the cost and performance assumptions for renewable energy technologies, we recommend that the EPA conduct additional modeling scenarios to better understand the costs and benefits of increasing renewables to achieve deeper CO_2 reductions. These scenarios could include:

---

[160] EPA Regulatory Impact Analysis, p. 3-9.

[161] EPA Regulatory Impact Analysis, Table 3-11.

- Requiring the model to at least meet the renewable energy targets from the EPA's Proposed, Alternative or any updates of these approaches; the UCS Demonstrated Growth Rate Approach or Market Penetration Approach (see below); NRDCs Alternative RE Approach; or other approaches. This could also be done in combination with the energy efficiency building block targets and achieving higher state emission reduction targets.
- Including a national or regional carbon price that increases gradually over time to achieve the EPA's existing state emission rate targets as well as higher targets, instead of reducing the cost of new renewable builds by $30/MWh.
- Conducting sensitivity runs to the scenarios above that assume higher and lower natural gas prices, given the high level of uncertainty in projecting future natural gas prices. We would recommend using EIA's high and low gas price projections from AEO 2014.

UCS ReEDs modeling was conducted by requiring the model to meet the renewable energy targets from our Demonstrated Growth Approach to analyze the impacts on CO_2 emission, electricity and natural gas prices, and the generation mix, as discussed in more detail above. An important benefit of this approach is that it more fully captures the energy diversity benefits of renewables displacing natural gas and lowering natural gas prices and bills, which in turn can offset modest increases in electricity prices. Reducing the economic risks of a potential overreliance natural gas by increasing renewables and efficiency is an important issue to many states that can justify adopting higher renewable energy targets compared to using the EPA's more conservative economic criteria. Some states have also been willing to pay higher incremental costs for renewables in the near-term to encourage technology innovation, attract new industries, and achieve economies of scale that will help drive down costs over the long-term. This approach has clearly been effective over the past 5-10 years in driving down the costs of both wind and solar.

We also recommend that the EPA work with NREL to run these scenarios in the latest version of the ReEDs model. The ReEDs model was specifically designed to more accurately model the costs and benefits of increasing renewables and overcome some of the limitations of other modeling platforms like IPM and NEMS that have a more simplistic representation of renewables.

6.4.2. The EPA should recognize regional differences in renewable energy market penetration rates and account for existing state commitments to deploy renewable energy.

As a second option for improving the EPA's Alternative Approach, UCS developed a modified approach for calculating state renewable energy targets based on technical potential and market penetration called the UCS "Market Penetration Approach." This approach differs from the EPA's Alternative Approach primarily by considering regional differences in renewable energy technology market penetration rates, and assuming states with RES policies achieve full compliance with these laws, like the UCS Demonstrated Growth approach. It also utilizes the most current renewable generation data available from EIA for 2013 (instead of 2012), including generation from distributed solar PV, which the EPA did not include.[162]

To calculate 2030 state renewable energy targets, we first divide 2013 renewable generation by NREL's estimated resource technical potential for the following technologies: utility scale PV, distributed PV, concentrating solar power (CSP), onshore wind, and conventional geothermal. These renewable market penetration percentages are then used to establish national and regional technology benchmarks. As in the EPA Alternative Approach, national benchmarks are calculated based on the average of the top third highest performing states for each technology (16 states). Due to the low number of states currently generating power with geothermal and CSP, the benchmarks for these technologies are based on a smaller subset of states, 6 states and 3 states, respectively.

Next, we calculate regional benchmark penetration rates based on the average of the top three performing states within each of the regions as defined by the EPA. Regional benchmarks are established to account for the variation in resource potential and utilization across different areas of the country, such as the relatively high market penetration of wind and solar resources in leading states located in the East Central region. Then, we calculate 2030 renewable energy targets by multiplying each state's technical potential for each technology by the greater of either the national or regional benchmark for that technology.

In addition to the technologies described above, we include existing biopower and new hydropower generation, using the EPA's methodology for assessing the potential contribution of these technologies. The potential for new hydropower in 2030 is estimated by subtracting 2013 hydro generation from NREL's estimate of hydropower potential for each state. Biopower and hydropower generation are added to the benchmarked technologies in order to calculate combined 2030 renewable energy targets.

---

[162] Energy Information Administration (EIA). 2014. Electricity data browser. Washington, DC: U.S. Department of Energy. Online at www.eia.gov/electricity/data/browser/, accessed on September 15, 2014.

As in our Demonstrated Growth Approach, the share of each state's renewable energy generation is capped at 40 percent of total electricity sales. Consistent with the EPA's proposed approach, state renewable energy targets for the Market Penetration Approach begin in 2017. EIA renewable generation data from 2013 and projected generation from wind and utility scale solar projects known to be under construction are used to estimate 2016 baseline generation.[163] Linear renewable energy growth is assumed beginning in 2017 through 2030 to achieve final renewable energy generation targets. Finally, in each year, it is assumed that states will achieve the greater of either the calculated renewable generation or the level needed to meet their mandatory RES target for that year as projected by LBNL[164], consistent with the EPA's "no backsliding" policy approach.[165]

The UCS Market Penetration Approach results in a 2030 national renewable energy target of 912,660 GWh (excluding existing hydropower) or 21 percent of total U.S. electricity sales in 2030. This is a significant increase over either the EPA proposed or alternative approach, both of which result in approximately 520,000 GWh of renewable generation or 12 percent of U.S. electricity sales. The UCS approach leads to higher renewable generation targets than the EPA Alternative Approach in the majority of states. However, by imposing the renewable generation cap of 40 percent of electricity sales, it also avoids placing an undue burden on states with high renewable potential and low electricity sales. For example, under the EPA's Alternative Approach, Kansas and South Dakota have 2030 renewable targets that are higher than 100 percent of their projected electricity sales.

We also recommend further consideration of offshore wind and new biopower generation, which are not included in the either the UCS Market Penetration Approach or the EPA Alternative Approach. Improvements to these and other renewable energy technology cost, performance, and resource potential assumptions are discussed in more detail in section 6.4.1.1.

Table 6-2. UCS Market Penetration Target Renewable Generation, Excluding Existing Hydropower (GWh).

State	2020	2025	2030
AL	3,250	3,250	3,250
AK	943	1,943	2,943
AZ	5,302	7,985	8,867
AR	3,305	5,365	7,424
CA	92,177	96,810	101,203

---

[163] Wind projects under construction are based on data from the American Wind Energy Association's U.S. Wind Industry Second Quarter 2014 Market Report, online at http://awea.files.cms-plus.com/FileDownloads/pdfs/2Q2014%20AWEA%20Market%20Report%20Public%20Version%20.pdf. Utility solar PV projects under construction are based on data from SNL Energy's Power Projects Database.

[164] Lawrence Berkeley National Laboratory (LBNL). 2013. Renewables portfolio standards resources. Online at http://emp.lbl.gov/rps, accessed on September 15, 2014.

[165] Proposed Rule, 34917.

CO	14,213	20,993	27,773
CT	7,193	7,260	7,224
DE	1,713	2,220	2,270
FL	4,805	4,908	5,011
GA	3,704	3,704	3,704
HI	2,619	3,543	4,467
ID	5,805	9,087	12,369
IL	26,158	45,046	63,934
IN	15,490	29,376	43,261
IA	19,668	20,573	21,478
KS	14,048	16,192	18,337
KY	749	1,273	1,797
LA	2,721	2,846	2,971
ME	4,890	4,960	5,031
MD	11,903	13,224	13,525
MA	10,575	13,197	15,636
MI	11,341	15,085	18,829
MN	19,041	25,156	31,272
MS	2,225	3,120	4,015
MO	11,832	24,949	38,065
MT	3,293	5,253	7,214
NE	5,938	9,904	13,870
NV	6,235	7,241	8,248
NH	2,154	2,687	2,674
NJ	18,562	19,501	20,093
NM	6,685	9,318	11,952
NY	10,546	10,546	10,546
NC	9,385	10,009	10,554
ND	6,791	7,027	7,263
OH	14,880	27,062	39,244
OK	18,218	23,383	28,548
OR	9,840	11,362	12,885
PA	11,939	12,311	12,592
RI	1,289	1,301	1,294
SC	1,965	1,965	1,965
SD	3,696	4,630	5,563
TN	1,142	1,145	1,149
TX	96,395	136,990	177,585
UT	3,647	6,740	9,832
VA	4,291	6,074	7,856
WA	12,436	13,089	13,623

WV	2,227	3,254	4,281
WI	12,350	21,362	30,374
WY	5,670	7,233	8,797
Total	**565,244**	**741,453**	**912,660**

*For more information on annual targets, see Appendix 1 and the attached spreadsheet.

6.5. UCS recommends the EPA use and, where necessary, expand on existing regional renewable energy credit (REC) tracking systems for compliance with the CPP and to help prevent double counting.

Under the State Plans section of the Proposed Rule, the EPA requests comment on several options for accounting for the interstate effects of implementing renewable energy technologies and for avoiding potential double counting of CO_2 reductions.[166] We support the EPA's proposed approach of assigning the CO_2 reductions and other attributes to the purchaser of renewable energy or RECs, regardless of where the renewable generation is physically located. We also support the use of existing regional REC and generation tracking systems (Figure 6-8) as best approach for tracking renewable energy compliance with the CPP and to help prevent potential double counting of renewable generation and CO_2 reductions.

---

[166] Proposed Rule, pp. 34921-34922.

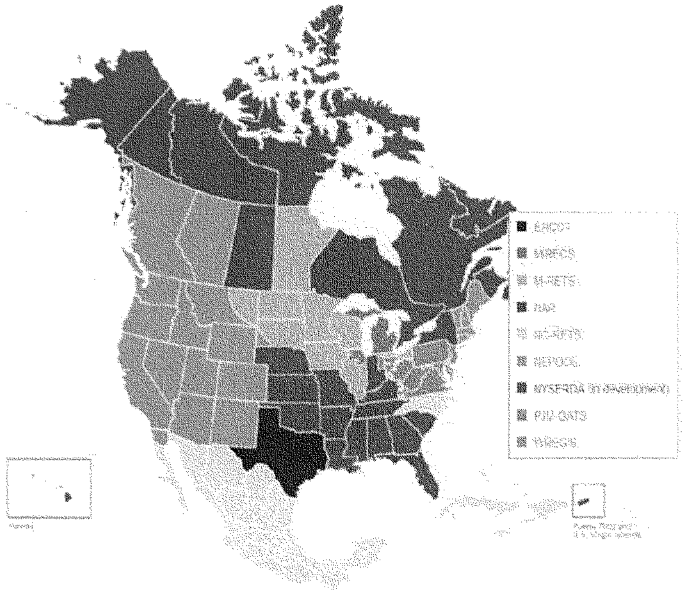


Figure 6-8. North American Renewable Energy Credit and Generation Tracking Systems.[167]

An important advantage of using these systems is that they are already set up to track compliance with existing state RES laws and verify claims for emission reductions and other attributes of RECs that are purchased through voluntary markets.[168] In addition, the NEPOOL GIS and PJM-GATS systems in the Northeastern U.S. are set-up to track all generation sources to support power source disclosure programs and to track CO_2 emissions, other pollutants, and other power attributes. These all generation tracking systems are also designed to match the emissions and other attributes of electricity supply with demand within a region and for imports into a region, which could also help facilitate compliance with state implementation plans. Some systems (NEPOOL GIS, NAR, and NC-RETS) are also being used to track energy savings from energy efficiency projects.

---

[167] APX Research, 2014. Using tracking systems with the implementation of Section 111d State Plans. Online at http://www.narecs.com/wp-content/uploads/sites/2/2014/10/APXAnalytics_1_Section111d.pdf.

[168] For more details on how regional REC tracking systems can be used for compliance with the CPP and to avoid double counting, see APX Research. 2014 andQuarrier, R. and D. Farnsworth. 2014. Tracking renewable energy for the U.S. The EPA's Clean Power Plan: Guidelines for states to use existing REC tracking systems to comply with 111(d). Prepared by the Center for Resource Solutions and Regulatory Assistance Project. Online at http://www.resource-solutions.org/pub_pdfs/Tracking%20Renewable%20Energy.pdf.

Under this approach, every megawatt-hour of eligible renewable generation would be assigned a tradable REC that could be used for state compliance with the CPP. The RECs could either be bundled with the physical delivery of the electricity, as required by some state RES laws, or unbundled and sold separately, which is also allowed for at least partial compliance in some state RESs (e.g., North Carolina). If the RECs are bundled with the delivery of the power to the state or regional power pool, it is reasonable to assume that the CO_2 reductions will occur within the state or region and to allocated those reductions to the purchasing state based on their regional share of the total REC purchases. This approach would also work well for states that are part of multi-state plans. If the RECs are unbundled and sold to a state outside of the region where the renewable generation is located, an adjustment would be needed to transfer the emission reductions from the generating state or region to the purchasing state. Several tracking systems already have the ability to track unbundled REC imports and exports between regions and tracking systems.

While allowing the use of unbundled RECs for state compliance with the CPP introduces some accounting complexities, it has the important advantages of giving states more flexibility in complying with the rule and lowering the cost of compliance, as shown by our ReEDS modeling of our proposed approach. And while states that sell RECS to other states would not be able to use those RECs or the associated renewable generation installed in their state for compliance, they would receive important economic benefits such as revenue from the sale of RECs as well as the construction, operation and manufacturing jobs and other local economic development benefits.

Voluntary renewables/green power. We also recommend making an adjustment for the emission reductions associated with REC purchases by the voluntary renewables/green power market. Customers who voluntarily purchase renewable energy want to know that they are achieving incremental emission reductions and other environmental benefits that go beyond what is required under existing laws. To ensure the validity of these claims and avoid double counting, states should not be allowed to use these RECs or emission reductions for compliance with the CPP. We suggest using a similar approach as the NEPOOL GIS and WREGIS tracking systems that makes an adjustment for the voluntary market related to the implementation of RGGI and California's cap and trade markets.

While we believe participation in an existing REC or generation tracking system is the most effective means for demonstrating compliance and avoiding double counting, there are at least two other approaches that could also be acceptable in addition to REC tracking. This includes renewable generation from 1) power purchase agreements and 2) facilities owned by utilities that are being used for compliance with state RESs or to meet voluntary state renewable energy goals, but are not part of REC tracking systems. However, to be eligible for compliance with the rule, the EPA should require states to demonstrate that the renewables generation and associated CO_2 reduction from these approaches is not being claimed by another state. As stated above, the general principle should be that the renewable generation and the associated CO_2 reductions and other attributes should go to purchaser of this generation, regardless of where the generation is located. The CO_2 reductions could be estimated by either using a marginal or average emissions rate for the power pool.

6.6. UCS recommends the EPA set renewable energy targets at the state level, but allow states to comply at a regional level.

In the Notice of Data Availability (NODA) from October 28, 2014, the EPA requested comment on whether to set renewable energy targets at a regional level and then assign shares of those regional targets to individual states in recognizing the interstate nature of the electricity system. Our recommendation is to set targets at the state level, but allow those targets to be met with renewable generation or RECs that are purchased from other states both within and outside a given region, as discussed in section 6.5. We are also supportive of implementing multi-state regional approaches as a more flexible, low cost way of complying with the rule, as discussed in more detail in section 9 of our comments.

Our recommended Demonstrated Growth Approach can easily be implemented on a regional level, by aggregating state targets to whatever regions provide greatest congruence with the organization of the electricity grid and simplify state implementation. As an example, Figure 6-2 above aggregates the state targets from our approach to the regions specified in the EPA's Proposed Approach.[169] We also support aggregating state targets to regions defined by NERC, Regional Transmission Organizations (RTOs), or Independent System Operators (ISOs), with some adjustments, as those regions do not coincide with state boundaries in most cases. A recent UCS report discusses the benefits of regional grid coordination and highlights several recent studies by grid operators showing that renewable energy can significantly lower CO_2 emissions while maintaining reliable and affordable electricity.[170] As with state targets, allowing nationwide trading of RECs for compliance would give states the option to find the lowest cost compliance options.

6.7. UCS supports the EPA's proposed approach for counting emissions reductions from new and incremental renewable energy, nuclear energy, and energy efficiency, and for only allowing new and incremental hydro to count for compliance.

The EPA also requested comment in the NODA on whether Building Blocks 3 and 4 should be treated in the same manner as natural gas fuel switching in Building Block 2 by counting the emission reductions for renewables, nuclear, and efficiency in the numerator of the emission rate formula rather than just the generation in the denominator. We strongly agree with this approach as these technologies are clearly reducing CO_2 by displacing fossil generation and it's a more consistent and equitable approach with how natural gas fuel switching is treated. However, only the CO_2 reductions from new and incremental renewables (including hydro), nuclear and efficiency should be counted, as the CO_2 reductions from existing renewables (including hydro), nuclear and efficiency are already embedded in the baseline emissions and generation mix. As discussed in more detail in section 11, we believe that the incremental generation from zero carbon options should be assumed to displace fossil fuels (and the associated CO_2 emissions) on a pro-rata basis, which is a better representation of the BSER and consistent with the treatment of incremental NGCC.

---

[169] The underlying data from this approach are included in the attached spreadsheet.

[170] UCS. 2014. Renewable energy on regional power can help states meet federal carbon standards. Online at http://www.ucsusa.org/renewablesandregionalgrids.

The EPA also requested comments on whether to include 2012 hydropower generation from each state under the proposed approach, and whether and how to consider year-to-year variability in hydropower generation.[171] We support the EPA's approach that excludes existing hydro in the state goal setting, but allows new and incremental hydro to count toward compliance. Like existing nuclear generation, existing hydro is a mature technology that doesn't need economic support under the CPP in most cases. If the EPA decides to include existing hydro in the state renewable targets, we would suggest basing it on a rolling average of three most recent years of data to smooth year-to-year variability.

6.8. UCS recommends that the EPA include incentives for early action.

We support incentives for early action to encourage investments renewables and energy efficiency and a shift away from fossil-fired generation, including in the pre-2020 period after a state compliance plan has been approved by the EPA, as long as these incentives do not undermine the overall level of emissions reductions achieved by the CPP. The quicker we can cut emissions, the better from a climate perspective.

6.9. UCS recommends that the EPA use the most recent renewable generation data available, include renewable energy projects that are under construction through 2016, and assume states with RESs at least meet their mandatory targets.

The EPA is requesting comments on whether each state's goal should be modified to include a floor based on reported 2012 renewable generation to address the problem that some state targets in the EPA's proposed approach are less than 2012 levels.[172] While this would be an improvement, assuming some states won't increase renewable generation over current levels doesn't go far enough. We addressed this problem under our recommended approaches described above in several ways, including: 1) using 2013 renewable generation data from EIA as the starting point, 2) including wind and utility solar under construction from 2014-2016, and 3) assuming states with RESs at least meet their mandatory targets as projected by LBNL, which is consistent with the EPA's "no backsliding" policy principle.[173]

---

[171] Proposed Rule, 34869.
[172] Proposed Rule, 34868.
[173] Proposed Rule, 34917.

7. Nuclear Power: Building Block 3

- **UCS supports the EPA's proposal to include new nuclear reactors that are under construction in setting state emission reduction targets and for compliance, which is consistent with the EPA's treatment of new natural gas combined cycle plants and UCS's recommendation for new renewables that are under construction.**
- **UCS recommends excluding existing "at-risk" nuclear generation from the formula for setting state emission reduction targets, as the number of at-risk reactors is limited, site specific, and will likely decline over time as natural gas and wholesale electricity prices rise.**
- **UCS does not support allowing existing plants that may receive a license extension beyond 60 years to be counted as new generation for the purposes of compliance, given important safety issues that are outside of the EPA's jurisdiction.**

UCS believes that the cuts in heat-trapping emissions that the U.S. and the rest of the world need to make to limit the worst consequences of global warming are so large, and the need to take action is so urgent, that we need to consider all potential options for reducing emissions, as described in our 2007 *Nuclear Power in a Warming World* report.[174] Nuclear power does not produce carbon emissions during operation, and has relatively low lifecycle carbon emissions that are comparable to many renewable technologies. But these benefits need to be weighed against the safety and security risks, the waste disposal challenges, and the water requirements of nuclear power. The high cost and long lead time required for large-scale deployment of new nuclear plants must also be considered. Other low- and zero-carbon technologies like energy efficiency and renewable energy have fewer risks, are already cost-effective in many places, and can be deployed more quickly at a large scale.

UCS is particularly concerned about the potential impacts of the rule's treatment of nuclear power on the safety and security of both operating nuclear plants and the five reactors currently under construction. While we understand that nuclear safety is not within the EPA's jurisdiction, the agency cannot ignore the potential indirect effects of the rule in providing incentives to keep "at risk" plants operating. An operating nuclear plant's "at risk" status depends on many factors, but one of them is the extent to which a plant's bottom line is affected by evolving safety and security requirements. For instance, the NRC increased security requirements after the 9/11 attacks, but it is well known that the industry lobbied heavily to keep them to a minimum because of their cost.[175] Similarly, in the wake of the 2011 Fukushima accident, the industry has pushed back on certain proposed additional safety requirements such as filtered venting systems for boiling-water reactors.[176] The NRC has also waived certain post-Fukushima safety requirements for the AP1000 reactors now under construction based on a faulty assumption that those plants will be safer than current plants. The EPA needs some mechanism—perhaps through a memorandum of understanding with the NRC—to help ensure that in mitigating the risk of climate change it does not increase the risk of a catastrophic nuclear accident or terrorist attack.

---

[174] Gronlund, L., D. Lochbaum, and E. Lyman. 2007. Nuclear Power in a Warming World: Assessing the Risks, Addressing the Challenges. Cambridge, MA: Union of Concerned Scientists. Online at http://www.ucsusa.org/sites/default/files/legacy/assets/documents/nuclear_power/nuclear-power-in-a-warming-world.pdf.

[175] Lyman, E. 2010. Security since September 11th. Nuclear Engineering International. May. Online at http://www.neimagazine.com/features/featuresecurity-since-september-11th/.

7.1. UCS supports the EPA's inclusion of new nuclear reactors that are under construction in setting state emission reduction targets and for compliance.

Recognizing the potential for nuclear to reduce carbon emissions from existing fossil fuel power plants, we support the EPA's proposal to include new nuclear reactors that are currently under construction in setting state emission reduction targets and for compliance. This approach is consistent with the EPA's treatment of new natural gas combined cycle plants and UCS' recommendation for new renewables that are under construction. However, while these technologies are currently cost-effective to deploy on a larger scale for the purposes of the BSER (as discussed elsewhere in our comments), new nuclear plants are not. Thus, we agree with the EPA's approach for not including any additional new nuclear reactors beyond the ones that are under construction for setting state targets because of their current high costs and long lead times. However, states would have the flexibility to include additional nuclear plants for compliance under the proposed rule. We also believe the incremental generation from uprates, at existing plants that meet important safety standards, such as those described above, should be eligible for compliance.

7.2. UCS recommends that the EPA exclude existing "at-risk" nuclear generation from the formula for setting state emission reduction targets.

Existing nuclear reactors have been facing economic pressures due primarily to low natural gas and wholesale electricity prices, and expensive age- or safety-related repairs. As the EPA highlights in its GHG abatement measures technical support document, five reactors representing 4.2 GW of capacity were recently shut down for these reasons. These include the Kewaunee plant in Wisconsin and the Vermont Yankee plant, which were closed primarily for economic reasons, and Crystal River 3 in Florida and San Onofre 2 and 3 in California, which were closed primarily due to expensive repairs and safety concerns. In addition, the Oyster Creek plant in New Jersey is expected to close by 2019. UCS recommends excluding existing "at-risk" nuclear generation from the state emission reduction target formula, as the number of at-risk reactors is limited, site specific, and will likely decline over time as natural gas and wholesale electricity prices rise.

---

[176] Lipton, E. and M. Wald. 2013. Post-Fukishima, Arguments for Nuclear Safety Bog Down. *The New York Times*. February 26. Online at http://www.nytimes.com/2013/02/27/business/energy-environment/a-divisive-debate-on-need-for-more-nuclear-safeguards.html.

7.2.1. The economic pressure due to low natural gas and wholesale electricity prices is not unique to nuclear power.

The economic competitiveness of coal and oil-fired power plants, renewable energy facilities, and even energy efficiency investments are also affected by low market prices. Like nuclear, many older coal plants have needed to make expensive capital investments to replace aging equipment, improve plant efficiency, and install pollution control and other equipment to reduce air pollution and water use, and were forced to retire. However, unlike existing nuclear plants, which have been experiencing increasing costs over the past 10 years,[177] the costs of renewable energy technologies like wind and solar have been falling rapidly. This has allowed renewables to remain competitive with new natural gas plants in states with high quality resources.

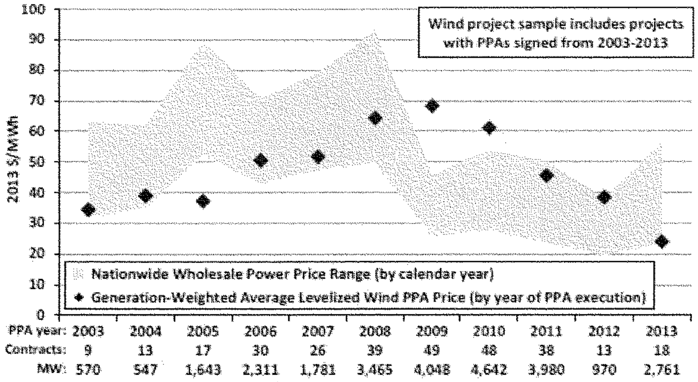
For example, a recent DOE report shows that the cost of new wind projects dropped by over 60 percent between 2009 and 2013, allowing them to remain competitive with declining wholesale electricity prices in some parts of the country, as shown in Figure 7-1 below.[178] However, this varies greatly by region, with weighted average wind power purchase agreement (PPA) prices between 2011 and 2013 within the range of average annual wholesale electricity prices in 2013 in the interior region of the country (i.e., Plains states), and slightly higher than average wholesale prices in the Northeast, Great Lakes and Western regions.[179]

---

[177] Based on data from the Electric Utility Cost Group on p.7, "Nuclear Energy 2014: Status and Outlook," Nuclear Energy Institute Annual Briefing for the Financial Community, February 13, 2014. Online at http://www.nei.org/CorporateSite/media/filefolder/Policy/Wall%20Street/WallStreetBriefing2014.pdf?ext=.pdf.

[178] Wiser, R., and M. Bolinger. 2014. 2013 wind technologies market report. Washington DC: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Online at http://eetd.lbl.gov/sites/all/files/2013_wind_technologies_market_report_final3.pdf, accessed on September 22, 2014.

[179] Wiser and Bolinger, 2014. See Figure 48 on p. 61.



Source: Berkeley Lab, FERC, Ventyx, IntercontinentalExchange

Figure 7-1. Average Levelized Long-term Wind PPA Prices and Yearly Wholesale Electricity Prices Over Time. *Source: Berkeley Lab, FERC, Ventyx, Intercontinental Exchange.*

7.2.2. Determining whether an existing plant is "at risk" is very plant specific.

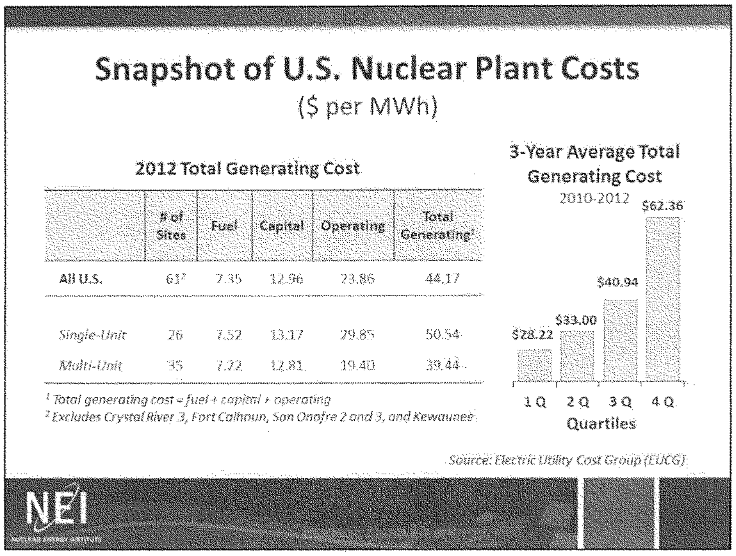
As discussed in a 2013 paper by Amory Lovins,[180] determining whether an existing nuclear plant is at-risk economically "depends on complex and shifting set of both market and plant-specific considerations, so no comparison of average conditions in a specific year can support conclusions about any individual plant." These considerations include the location, size, age, condition, and ownership of the plant. As shown in the figure above, wholesale prices vary widely across the country and over time. They also reflect the existing generation mix, which could shift over time. Nuclear plants located in states with below average market prices, excess capacity, high quality wind and solar resources, or strong energy efficiency programs tend to be more vulnerable. Merchant plants located in restructured markets tend to be more vulnerable than plants owned by regulated utilities. Smaller, single unit plants tend to be more expensive to operate than larger multi-unit plants, which are better able to spread out the costs of capital investments. The age and condition of the plant also makes a big difference, as older reactors tend to have higher operating costs and face more costly repairs to replace aging and damaged equipment.

Nuclear industry operating cost data that divides the 104 operating U.S. reactors into quartiles shows that at least three-quarters of U.S. reactors have 3-year average total generating costs that are within the lower to middle end of the range of 2013 wholesale electricity prices.[181] While the average costs of the remaining 25 percent have been higher than wholesale prices since 2009, they are in the middle of the range of wholesale prices between 2005 and 2008 when natural gas prices were higher.

---

[180] Lovins, A. 2013. The economics of a U.S. civilian nuclear phase-out. Bulletin of the Atomic Scientists 69(2):44-65, doi:1177/0096340213478000. Online at http://bos.sagepub.come/content/69/2/44.full.

[181] Based on data from the Electric Utility Cost Group on p.6, "Nuclear Energy 2014: Status and Outlook," Nuclear Energy Institute Annual Briefing for the Financial Community, February 13, 2014.



Snapshot of U.S. Nuclear Plant Costs

($ per MWh)

2012 Total Generating Cost

	# of Sites	Fuel	Capital	Operating	Total Generating[1]
All U.S.	61[2]	7.35	12.96	23.86	44.17
Single-Unit	26	7.52	13.17	29.85	50.54
Multi-Unit	35	7.22	12.81	19.40	39.44

[1] *Total generating cost = fuel + capital + operating*

[2] *Excludes Crystal River 3, Fort Calhoun, San Onofre 2 and 3, and Kewaunee*

3-Year Average Total Generating Cost

2010-2012

Source: Electric Utility Cost Group (EUCG)

Figure 7-2. U.S. Nuclear Plant Generating Costs. *Data from the Electric Utility Cost Group and the Nuclear Energy Institute shows that the costs of generating electricity from existing nuclear plants can vary greatly by location, size, age, condition, and ownership of the plant.*

7.2.3. The EPA's methodology of applying EIA's estimate of at-risk nuclear plants to the states is flawed.

The EPA's methodology for quantifying at-risk nuclear generation is based on EIA projections from its Annual Energy Outlook 2014 reference case.[182] EIA's analysis assumed an additional 6 GW of generic retirements would occur between 2012 and 2019, and represented this by assuming a reduced capacity for all existing plants in vulnerable regions (primarily in restructured markets with merchant plants). EIA did not assume retirements of specific plants. It also did not assume plants are at-risk of early retirement in every state that has existing nuclear plants, which the EPA does assume in its methodology. EIA also does not clearly explain how it came up with the additional 6 GW of retirements. However, EIA does indicate that they did not include any retirements after 2020 because natural gas prices in its reference case are projected to be high enough to "support the continued operation of the U.S. nuclear fleet and limit retirements from 2020 through 2040."

---

[182] See pp. IF34-IF38 of Energy Information Administration (EIA) 2014. *Annual Energy Outlook 2014.* Washington, DC: U.S. Department of Energy.

Additional fuel switching from coal to natural gas under the Clean Power Plan could increase natural gas prices above EIA's reference case projections before 2020, which in turn would increase the profitability of existing nuclear plants and potentially offset EIA's assumed retirements. In fact, under the CPP, the EPA's IPM modeling projects a 10.2 percent to 14.3 percent increase in power sector natural gas use in 2020 that results in a 7.5 percent to 11.5 percent increase in delivered natural gas prices to the electric power sector by 2020.[183] The EPA's modeling also does not show any difference in nuclear generation or capacity in 2020, 2025, or 2030 under any of the CPP scenarios compared to their Base Case.[184] Thus, the EPA's own modeling does not show that existing nuclear generation is at risk of early retirement, which is consistent with EIA's projections after 2020.

Recent UCS modeling using a modified version of EIA's AEO 2013 National Energy Modeling System (NEMS) and NREL's 2014 version of the Regional Energy Deployment System (ReEDs) model also does not project any near-term or long-term retirements of existing nuclear plants beyond the six reactors that recently closed or are projected to close in the next few years.[185] This is not surprising as both the EPA and UCS modeling use EIA's natural gas price projections.

The spikes in natural gas and wholesale electricity prices last winter due to extremely cold weather and the competition for natural gas for electricity generation and home heating are another example of how natural gas prices have already exceeded EIA projections. It is also worth noting that existing nuclear plants made considerable profits between 2005 and 2008 when annual wholesale electricity prices ranged from $43-93/MWh (2013$) due to record high natural gas prices.[186] This is illustrated in Figure 7-3 below from Exelon, which shows a strong correlation between their share price and natural gas prices over the past decade.[187]

---

[183] See Tables 3-16, 3-19, and 3-20 on pp. 3-36 to 3-38 of the EPA's *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants*. June 2014.

[184] See Tables 3-11 and 3-12 on pp. 3-25 to 3-34 of the EPA's *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants*. June 2014.

[185] Cleetus, R., S. Clemmer, J. Deyette, and S. Sattler. 2014. Climate Game Changer: How a carbon standard can cut power plant emissions in half by 2030. Cambridge, MA: Union of Concerned Scientists. Online at http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/Carbon-Standards-Analysis-Union-of-Concerned-Scientists.pdf. UCS. 2014. Strengthening the EPA's clean power plan: Increasing renewable energy use will achieve greater emission reductions. Cambridge, MA: Union of Concerned Scientists. Online at http://www.ucsusa.org/renewablesandcleanpowerplan.

[186] Wiser 2014.

[187] Goggin, M. 2014. The facts about wind energy's impact on electricity markets: Cutting through Exelon's claims about "negative prices" and "market distortion." American Wind Energy Association.

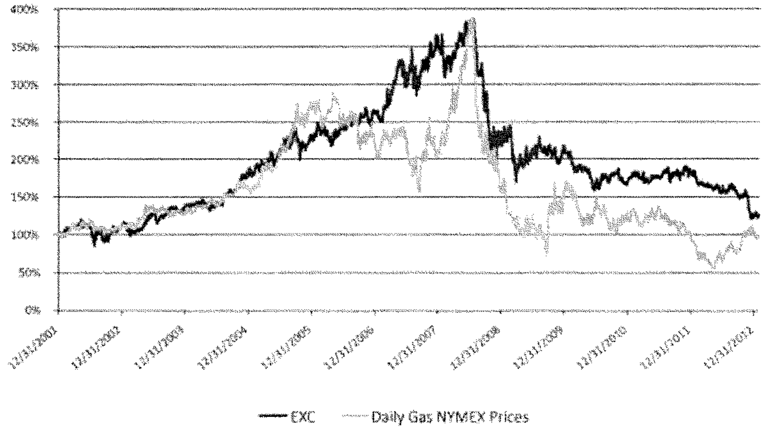


Figure 7-3. Exelon's (EXC) Stock Value is Highly Correlated with Natural Gas Prices.
Source: Exelon Generation.[188]

Because early retirements of nuclear plants appear to be a temporary issue, and would likely be limited to a few specific plants and locations, we do not believe the EPA should include "at-risk" nuclear generation in the formula for setting state emission reduction targets. In addition, the emission reductions from existing plants are already reflected in state's base emissions and generation mix. For similar reasons, we are also recommending that existing renewables be excluded from the EPA's formula for setting state targets, as discussed in more detail in section 11.5 of our comments.

However, if a limited number of existing nuclear plants are retired early and replaced with natural gas, it could result in net increase in a state's emissions, all other things being equal. But it's also possible that existing plants could be replaced with a combination of new renewables and energy efficiency without increasing emissions. Recent analyses by UCS, the National Renewable Energy Laboratory (NREL), and Rocky Mountain Institute all show that the U.S. could gradually phase out existing nuclear reactors by the time they reach 60-years of operation and replace them primarily with renewables and energy efficiency, while saving consumers money, maintaining reliability, and significantly reducing carbon emissions and water use.[189] Thus, we believe the determination of existing at-risk nuclear plants should be addressed on a case by case basis in state compliance plans and supported by a comprehensive analysis of the costs and benefits of keeping existing plants open vs. retiring and replacing them with other low and zero carbon generation.

---

[188] Exelon Corporation. 2013. Schedule 14A, U.S. Securities and Exchange Commission. Online at http://www.sec.gov/Archives/edgar/data/1109357/000119312513107079/d474444ddef14a.htm.

[189] See Lovins 2013, and Clemmer, S., J. Rogers, S. Sattler, J. Macknick, and T. Mai. 2013. Modeling low-carbon US electricity futures to explore impacts on national and regional water use. *Environmental Research Letters* 8 (2013) 015004. Online at http://iopscience.iop.org/1748-9326/8/1/015004/.

This approach would also help limit the potential for providing additional subsidies and windfall profits to existing nuclear plants that do not need them to continue operating. A 2011 UCS report shows that existing nuclear plants have already received generous subsidies that have cost taxpayers more than the market price of power they helped generate, and they continue to receive ongoing subsidies ranging from 1 to 6 cents/kWh.[190] When nuclear power was an emerging technology, public support made sense. But more than 50 years (and two public bailouts) after the opening of the first U.S. commercial nuclear plant, nuclear power is a mature industry that should be expected to stand on its own. UCS believes that the best policy mechanism to value the low carbon benefits of nuclear power is to put a price on carbon. This would remove a market price distortion by internalizing a cost currently not factored into the price of coal and natural gas that would benefit nuclear, renewables and other low carbon options equally.

7.3. UCS recommends that the EPA not allow any existing nuclear reactors that receive a license extension beyond 60 years to be counted as new generation for the purposes of compliance.

According to EIA, the nuclear power industry is considering submitting applications to extend the operating licenses of existing plants for an additional 20 years that would allow them to continue operating beyond 60 years. To date, no reactor has applied for or received a license extension from the Nuclear Regulatory Commission (NRC) beyond 60 years, as most U.S. reactors will not reach this point until after 2030. Extending reactor licenses beyond 60 years raises important safety issues that will need to be carefully considered by the NRC, and are outside of the EPA's jurisdiction in this venue. If any existing reactors do receive an additional license extension, we do not believe they should be counted as new generation for the purposes of compliance.

---

[190] Koplow, D. 2011. Nuclear power: Still not viable without subsidies. Cambridge, MA: Union of Concerned Scientists. Online at http://www.ucsusa.org/sites/default/files/legacy/assets/documents/nuclear_power/nuclear_subsidies_report.pdf.

8. Energy Efficiency: Building Block 4

- **UCS recommends that the EPA use a target for incremental annual energy efficiency of at least 2.0 percent of electricity sales for each state, based on inclusion of a broader suite of energy efficiency policies, measures, and technologies in its calculation of state targets.**
- **UCS similarly recommends that the EPA use a target of at least 0.25 percent per year for the ramp-up rate, based on the broader suite of opportunities, and incorporate a differential approach for states at the lowest annual levels, to better reflect opportunities for states at low levels of efficiency development.**
- **UCS recommends that the EPA update its baseline year for energy efficiency targets to 2013 and update cost and performance assumptions for efficiency technologies and measures to reflect the most recent data on state-level energy efficiency programs, and incorporate a range of other strategies to ensure the integrity and effectiveness of Building Block 4, including with respect to interstate trading, voluntary actions, and improvements in transmission and distribution.**

The EPA's inclusion of energy efficiency as an eligible compliance option for states to reduce power plant carbon emissions is sensible and meets the criteria for the BSER. Energy efficiency, as a plentiful resource for meeting electricity needs and one that is almost always the lowest cost can appreciably improve the economics of reducing carbon, providing sustained reductions in energy use for consumers and businesses. As the EPA rightly notes, "there is considerable experience with the states and the power sector in designing and implementing demand-side energy efficiency improvement strategies and programs."[191]

The EPA also notes that:

> *"…demand-side energy efficiency supports not only reduced CO_2 emissions and carbon intensity of the power sector, but also reduced criteria pollutant emissions, cooling water intake and discharge, and solid waste production associated with fossil fuel combustion."*[192]

Those benefits are well documented. Regarding the cooling water issue, for example, research under the UCS-led Energy and Water in a Warming World initiative (EW3) found that high use of energy efficiency and renewable energy could lead to deep reductions in water impacts:

> *"A pathway focused on renewable energy and energy efficiency, we found, could deeply cut both carbon emissions and water effects from the power sector. Water withdrawals would drop 97 percent by 2050—much more than under business as usual. They would also drop faster, with 2030 withdrawals only half those under business as usual. And*

---

[191] Proposed Rule, 34906.

[192] *Ibid.*, 34871-2.

> *water consumption would decline 85 percent by 2050. This pathway could also curb local increases in water temperature from a warming climate.*"[193]

The EPA and others have also documented the even broader range of benefits that energy efficiency offers, such as locally sourced jobs, increased productivity, heightened comfort, higher property values, reduced price volatility, and greater energy security.[194]

Even without monetization of all those additional benefits, many analyses have documented the cost-effectiveness of energy efficiency and shown the potential for efficiency to dramatically reduce the costs of achieving given levels of carbon reductions. Consistent with the EPA's observations in the draft rule,[195] many analyses have found that high levels of energy efficiency, paired with high levels of renewable energy, can reduce costs or even produce consumer savings, with gains from efficiency offsetting any rate increases from other measures.[196]

The economics and potential of energy efficiency are such that the data support energy efficiency playing a much larger role in achieving the goals of the Clean Power Plan than currently proposed, and more inclusive assessments of efficiency costs and opportunities would allow the EPA to set stronger state targets. Analysis by the American Council for an Energy-Efficient Economy (ACEEE), for example, showed that energy efficiency alone could achieve CO_2 reductions of 26 percent below 2012 levels by 2030—at no net cost to the economy.[197]

Along with highlighting data and resources that support the EPA's proposals for including an appreciable role for energy efficiency in the BSER, we offer recommendations for strengthening Building Block 4.

---

[193] Rogers J., K. Averyt, S. Clemmer, M. Davis, F. Flores-Lopez, et al. 2013. Water-smart power: Strengthening the U.S. electricity system in a warming world. Cambridge, MA: Union of Concerned Scientists, Energy and Water in a Warming World Initiative. Online at http://www.ucsusa.org/sites/default/files/legacy/assets/documents/clean_energy/Water-Smart-Power-Full-Report.pdf.

[194] See, for example, the GHG Abatement Measures Technical Support Document (p. 5–9), and technical comments submitted by the Southwest Energy Efficiency Project (SWEEP) and the American Council for an Energy-Efficient Economy (ACEEE) on the Clean Power Plan (Docket ID EPA-HQ-OAR-2013-0602).

[195] "By reducing electricity usage significantly, energy efficiency also commonly reduces the bills of electricity customers" (Proposed Rule, 34871-2).

[196] See, for example: Cleetus, R., S. Clemmer, and J. Deyette. 2014. Climate Game Changer: How a carbon standard can cut power plant emissions in half by 2030. Cambridge, MA: Union of Concerned Scientists: May 2014. Online at http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/Carbon-Standards-Analysis-Union-of-Concerned-Scientists.pdf. Rogers J., K. Averyt, S. Clemmer, M. Davis, F. Flores-Lopez, et al. 2013. Water-smart power: Strengthening the U.S. electricity system in a warming world. Cambridge, MA: Union of Concerned Scientists, Energy and Water in a Warming World Initiative. Online at http://www.ucsusa.org/sites/default/files/legacy/assets/documents-/clean_energy/Water-Smart-Power-Full-Report.pdf. Cleetus R., S. Clemmer, and D. Friedman. 2009. Climate 2030: A national blueprint for a clean energy economy. Cambridge, MA: Union of Concerned Scientists. May 2009. Online at http://www.ucsusa.org/global_warming/solutions/reduce-emissions/climate-2030-blueprint.html#.VG-jEGcQPpw.

[197] Hayes, S., G. Herndon, J. Barrett, J. Mauer, M. Molina, M. Neubauer, D. Trombley, and L. Ungar. 2014. Change is in the air: How states can harness energy efficiency to strengthen the economy and reduce pollution. Washington, D.C.: American Council for an Energy-Efficient Economy. http://aceee.org/research-report/e1401.

8.1. UCS recommends that the EPA include a broader suite of existing energy efficiency policies, measures, and technologies, including building codes, state appliance efficiency standards, and combined heat and power.

Including a broader suite of tools and technologies in the Clean Power Plan, such as building codes, state appliance efficiency standards, and combined heat and power (CHP), is both consistent with current energy efficiency practice at the state level and appropriate given the demonstrated effectiveness of such approaches in achieving cost-effective energy reductions.[198] Some 40 states have mandatory statewide residential energy codes, for example, and around 42 states have commercial energy codes.[199] For CHP, studies demonstrate its cost effectiveness, and 23 states already include CHP in their energy efficiency or renewable energy standards.[200]

8.2. UCS recommends that the EPA use a target for incremental annual energy efficiency of at least 2.0 percent of electricity sales for each state, based on inclusion of the broader suite of energy efficiency policies discussed above.

Data suggest that the EPA is being overly conservative in its estimation of energy efficiency potential in assuming a 1.5 percent per year figure for incremental energy efficiency. Many leading states and utilities are achieving reductions at levels above 1.0 percent, and some are already meeting or exceeding the proposed rate of 1.5 percent.[201] Further, the EPA cites 11 states with state policies requiring annual reductions of at least 1.5 percent on or before 2020, for example.[202]

Incorporation of a fuller suite of energy efficiency tools such as those discussed above will better reflect current state practice and allow the EPA to set stronger state targets. The EPA itself notes the potential of incorporating a broader suite of energy efficiency opportunities:

> *"If we were to capture the potential for additional policies, such as the adoption and enforcement of state or local building energy codes, to contribute additional reductions in electricity demand beyond those resulting from energy efficiency programs, we could reasonably increase the targeted annual incremental savings rate beyond 1.5 percent."*[203]

---

[198] See, for example, the technical comments submitted by ACEEE and SWEEP, and Cleetus et al. 2014.

[199] Online Code Environment & Advocacy Network (OCEAN). 2014. Residential Code Status. Online at http://energycodesocean.org/code-status-residential, last accessed November 2014; see the technical comments submitted by ACEEE.

[200] US Department of Energy and US Environmental Protection Agency. 2012. Combined heat and power: A clean energy solution. Washington, D.C.: US Department of Energy and US Environmental Protection Agency. Online at http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf.

[201] For example, eight states (AZ, CO, ME, MD, MA, MN, RI, and VT) achieved incremental savings as a percent of retail sales of at least 1.5 percent in 2013, or the most recent available year (Gilleo, A., A. Chittum, K. Farley, M. Neubauer, S. Nowak, D. Ribeiro, and S. Vaidyanathan. 2014 State energy efficiency scorecard. Washington, D.C.: American Council for an Energy-Efficient Economy. http://www.aceee.org/sites/default/files/publications/researchreports/u1408.pdf.).

[202] By 2020, for example, AZ, CO, IL, IN, MA, MN, NY, OH, RI, VT, and WA are expected to meet or exceed an incremental savings of 1.5 percent according to state policies currently in place (GHG Abatement Measures TSD, p. 5–33).

[203] Proposed Rule, 34872; the EPA notes that studies show that building codes alone could account for 13-18 percent of projected reductions (GHG Abatement Measures TSD, p. 5–11).

Analysis by ACEEE has shown that such a multi-policy approach would indeed lead to significantly higher levels of efficiency. While they project that energy savings targets themselves would yield much of the electricity savings, adding even conservative levels of building energy codes, CHP, and state equipment efficiency standards would lead to 925 million MWh of savings—one-third more than with energy savings targets alone, as shown in the table below.[204] Such an approach would be equivalent to moving from a target of 1.5 percent to 2.0 percent.

Table 8-1. Electricity Savings in 2030 Based on Four-Policy Approach.

	Annual electricity savings (MWh)	Cumulative electricity savings (MWh)	Avoided capacity (GW)	Percent avoided electricity consumption relative to 2012
Energy savings target	692,200,000	5,470,500,000	185	18.8%
Building codes	155,400,000	1,100,100,000	41	4.2%
Combined heat and power	68,300,000	564,500,000	18	1.9%
Equipment standards	9,400,000	112,100,000	3	0.3%
National total for all four policies	925,400,000	7,247,200,000	247	25.1%

Source: Hayes et al. 2014.

UCS recommends that the EPA adopt an assumption of annual incremental improvements of 2.0 percent or higher, and increase the state targets accordingly.

UCS also recommends that the EPA take into account additional progress from leadership states in calculating state targets, as with renewable energy. Some states are set to be already achieving energy efficiency reductions at annual rates higher than the level the EPA proposes to use as the default.[205] The EPA should assume full compliance with current state energy efficiency policies, as set by law, including energy efficiency resource standards that require certain improvements in energy efficiency over time; the EPA should include those levels of efficiency in its plans for such states. That is, the EPA's default should be a floor, not a set point, as states with the most forward-leading EERS policies should not be projected to decrease their levels.

---

[204] Hayes, S., G. Herndon, J. Barrett, J. Mauer, M. Molina, M. Neubauer, D. Trombley, and L. Ungar. 2014. Change is in the air: How states can harness energy efficiency to strengthen the economy and reduce pollution. Washington, D.C.: American Council for an Energy-Efficient Economy. http://aceee.org/research-report/e1401.

[205] For example, AZ, ME, MD, MA, RI, and VT have now all achieved incremental savings at levels greater than 1.5 percent (Gilleo, A., A. Chittum, K. Farley, M. Neubauer, S. Nowak, D. Ribeiro, and S. Vaidyanathan. 2014 State energy efficiency scorecard. Washington, D.C.: American Council for an Energy-Efficient Economy. http://www.aceee.org/sites/default/files/publications/researchreports/u1408.pdf.).

8.3. UCS recommends that the EPA update its baseline year for energy efficiency targets to 2013, in place of 2012.

As with the renewable energy targets under Building Block 3, the EPA should use the most recent data available on state progress—2013, rather than 2012—as its baseline year.[206]

8.4. UCS recommends that the EPA use a target ramp-up rate of at least 0.25 percent per year, and incorporate a differential approach that assumes that states currently at the lowest annual levels rise more quickly to the target annual levels, to better reflect opportunities for states at low levels of efficiency development.

The experiences of leading states suggest that here, too, the EPA is being overly conservative in assuming a 0.20 percent ramp-up, particularly if the EPA incorporates the broader suite of energy efficiency policies in its target-setting. SWEEP and ACEEE, for example, document multiple cases of utilities achieving ramp-up rates of 0.25 percent or higher.[207] UCS recommends that the EPA adopt a minimum ramp-up rate of 0.25 percent to reflect the best data on recent experience at the state level, and incorporation of the broader suite of energy efficiency policies.[208]

UCS also recommends that the EPA adopt the proposal in the RGGI states' comments that the EPA use differential ramp-up rates based on the current status of state energy efficiency efforts, to provide for faster ramp-ups for states that have developed their efficiency potential less. As the RGGI states suggest, for such states that:

> *"... by year-end 2012 had not met or exceeded either the average U.S. total incremental savings as a percentage of retail sales (2012) or the average U.S. total cumulative savings as a percentage of retail sales (2012)... [,] the goal computation... should reflect* ***a targeted 0.38 percent rate of improvement of incremental annual savings per year****, as opposed to the 0.20 percent per year ramp-up schedule identified by the EPA in the current proposed goal computation."*[209]

8.5. UCS recommends that the EPA update its cost and performance assumptions for efficiency technologies and measures to reflect the most recent data on state-level energy efficiency programs.

In its calculations of the cost of projected activities under Building Block 4, the EPA assumes cost and performance estimates for energy efficiency measures and programs that do not reflect the latest data, resulting in unduly high cost assessments. Those estimates cover areas such as first-year program costs, product lifetimes, program costs over time, and levelized cost of saved energy (LCSE).

---

[206] In this, UCS concurs with, for example, the Advanced Energy Economy (AEE): "When finalizing the Clean Power Plan, the EPA should use the most up-to-date data available on energy savings rates as the starting point. The Clean Power Plan should then apply the growth factor to that rate for all years after finalization. This will more accurately capture the level of savings that would occur even before states adopt compliance plans, and will thus more accurately predict the quantity of savings achievable during the compliance period" (AEE technical comments submitted on the Clean Power Plan [Docket ID EPA-HQ-OAR-2013-0602]).

[207] See technical comments submitted by ACEEE and SWEEP.

[208] In this, UCS concurs again with the technical comments submitted by AEE: "AEE believes the 0.2 percent growth rate is conservative and encourages the EPA to adopt the more aggressive 0.25 percentage growth rate."

[209] See technical comments submitted by the Regional Greenhouse Gas Initiative (RGGI) states on the Clean Power Plan (Docket ID EPA-HQ-OAR-2013-0602); emphasis added.

First-year program costs. The EPA uses a national average first-year program cost of $275/MWh (2011$) for its accounting, based on a 2009 ACEEE report.[210,211] However, the EPA subsequently refers to lower values from two much more recent and comprehensive studies, from ACEEE and LBNL. The updated ACEEE report supports a figure of $230/MWh (2011$), based on analysis of utility programs in 20 states.[212] The LBNL report, drawing on findings from more than 1,700 individual programs studied for up to three years, supports a figure equivalent to approximately $175/MWh (2011$).[213]

Product lifetimes. The EPA's assumptions about measure lives—with uniform distribution of impacts across the projected lifetime—is clearly at odds with data from analyses of state energy efficiency programs, such as that by LBNL (Billingsley et al. 2014), as noted by AEE:

> *"Measures are significantly more likely to last between 10 and 15 years than to last between 0 and 5 years. Moreover, some passive efficiency improvements to home and building envelopes (e.g., insulation and air sealing) can be expected to have much longer measure lives. By assuming a uniform distribution, the Proposed Rule overestimates the amount of energy savings that expire in early years and therefore underestimates the amount of achievable savings over the Interim compliance period. The Proposed Rule should utilize the distribution of measure lives included in the LBNL study rather than the inaccurate assumption that measure lives are uniformly distributed."*[214]

Program cost increases. The EPA assumes program costs increase at higher levels of incremental annual savings, yet data suggest that an assumption of no increases would better match experiences with existing energy efficiency programs, as noted by ACEEE.[215]

LCSE. The EPA notes the conservative nature of its cost assumptions repeatedly, and the impact of this reserved approach on its final calculation of LCSE:

> *"The EPA has taken a conservative approach to each of these factors, selecting values that are at the higher-cost end of reasonable ranges of estimated values. The combination*

---

[210] GHG Abatement Measures Technical Support Document, p. 5–50.

[211] Friedrich, K., M. Eldridge, D. York et al. 2009. Saving energy cost-effectively: A national review of the cost of energy saved through utility-sector energy efficiency programs. Washington, D.C.: American Council for an Energy-Efficient Economy. http://aceee.org/research-report/u092.

[212] Molina, M. 2014. The best value for America's energy dollar: A national review of the costs of utility energy efficiency programs. Washington, D.C.: American Council for an Energy-Efficient Economy. http://www.aceee.org/sites/default/files/publications/researchreports/u1402.pdf.

[213] Billingsley, M.A., I. M. Hoffman, E. Stuart, S. R. Schiller, C. A. Goldman, K. LaCommare, Lawrence Berkeley National Laboratory. March 2014. The program administrator cost of saved energy for utility customer-funded energy efficiency programs. http://emp.lbl.gov/sites/all/files/cost-of-saved-energy-for-ee-programs.pdf.

[214] See technical comments submitted by AEE.

[215] See technical comments submitted by ACEEE.

> *of these factors is reflected in the value the EPA has derived for the levelized cost per MWh of saved energy.* "[216]

The EPA's overly conservative assumptions lead to higher levelized costs for energy savings than experiences seem to warrant. The EPA's approach leads to an LCSE of $85-$90/MWh, substantially higher than the $54/MWh cited by ACEEE.[217] As the Natural Resources Defense Council (NRDC) notes, "the EPA used extremely conservative energy efficiency costs that are 68–81 percent higher than current average costs," and "Numerous state programs have demonstrated consistently that energy efficiency programs cost significantly less than the estimate the EPA relied on in its analysis."[218]

UCS recommends that the EPA adopt for its projections and goal setting the most recent published data with regard to energy efficiency costs and lifetimes.[219]

8.6. UCS recommends that the EPA incorporate a range of other strategies to ensure the integrity and effectiveness of Building Block 4, including with respect to credit for efficiency actions in net-importing states, accounting for voluntary energy efficiency actions, prohibitions against double-counting, and credit for improvements in transmission and distribution.

UCS recommends that:

- **The EPA award full credit for energy efficiency measures implemented by net-importing states**, rather than discounting them based on percentage of imported energy.[220]
- **The EPA appropriately account for voluntary energy efficiency actions** by private actors not covered by the rule, so that such actions are not double counted by reducing any state's obligations under the rule.[221]
- **The EPA not allow double-counting of efficiency-based reductions**, including between a state using a rate-based and one using a mass-based approach.[222]
- **The EPA grant credit for improvements in transmission and distribution efficiency.**[223]

---

[216] Proposed Rule, 34874.

[217] Molina, M. 2014. The best value for America's energy dollar: A national review of the costs of utility energy efficiency programs. Washington, D.C.: American Council for an Energy-Efficient Economy. Online at http://www.aceee.org/sites/default/files/publications/researchreports/u1402.pdf.

[218] Natural Resources Defense Council (NRDC). 2014. The EPA's Clean Power Plan could save up to $9 billion in 2030. IB: 14-11-A. Online at http://www.nrdc.org/air/pollution-standards/files/clean-power-plan-energy-savings-IB.pdf.

[219] See, for example, the technical comments submitted by ACEEE.

[220] *Ibid.*

[221] This case is analogous to the voluntary renewable energy situation discussed in section 6.5.

[222] Per the recommendations of the RGGI states in their joint comments: "While a mass-based approach provides many advantages, for those states that elect to utilize a rate-based approach, the EPA should explicitly prohibit 'double-counting' of emission reductions from energy efficiency ('EE') and renewable energy ('RE') measures."

[223] See the technical comments submitted by SWEEP.

- **Municipal utilities and rural electric cooperatives be subject to the rule in the same manner** (no special treatment), consistent with the performance of leading municipal utilities and cooperatives.[224]

---

[224] *Ibid.*

9. Regional and Market-Based Approaches to Compliance with the Clean Power Plan

- **UCS supports the flexibility in the Clean Power Plan that allows states to comply with the emissions reductions requirements called for by the CPP on a regional or multi-state basis if they so choose because this can lead to lower cost emission reductions.**

- **We also support the inclusion of market-based approaches to compliance, including emissions trading programs, carbon caps and carbon revenue-raising options, as long as the emissions reductions achieved are equivalent to the state goals in the CPP.**

- **UCS recommends that EPA provide guidance, in the case of states that choose to use market-based approaches that generate carbon revenues, on using such revenues, in part, to support or retrain displaced workers, invest in renewable energy and energy efficiency programs, and provide assistance to low-income and environmental justice communities.**

9.1. UCS supports the EPA's inclusion of regional compliance options as a cost-effective, proven way to provide numerous benefits.

Regional compliance options allow states to find the most cost-effective compliance options across a number of states instead of being restricted to whatever resources may be available within a single state.[225] This could lower the costs of compliance with the standard. Allowing multi-state compliance takes account of the fact that the electricity grid already functions on a regional basis in order to secure greater benefits at lower cost for the states served. A multi-state approach builds on the experience and progress made by the Northeast states under the Regional Greenhouse Gas Initiative (RGGI). The existing REC-trading programs around the country are also models for how states across the nation cooperate in tracking and procuring zero-carbon resources and meet renewable electricity standards (RES).

Regional compliance options are a proven success. For example, the RGGI states have collectively lowered their emissions 40 percent below 2005 levels, and have raised more than $1.6 billion in carbon revenues that have benefitted the states' residents. The carbon cap prescribed by the program functions together with complementary energy efficiency and renewable energy programs in the states to deliver greater benefits at a lower cost.

---

[225] See, for example: Fowlie, M., L. Goulder, M. Kotchen, S. Borenstein, J. Bushnell, L. Davis, M. Greenstone, C. Kolstad, C. Knittel, R. Stavins, M. Wara, F. Wolak, C. Wolfram. 2014. An economic perspective on the EPA's Clean Power Plan: Cross-state coordination key to cost-effective CO_2 reductions. *Science* 14 November 2014:
Vol. 346 no. 6211 pp. 815-816. DOI: 10.1126/science.1261349.

9.2. UCS recommends that the EPA provide clear guidance to enable more states and regions to take advantage of the benefits of multi-state compliance options, should they so choose.

Support for multi-state/regional approaches was echoed in numerous stakeholder comments to the EPA. Most recently the RGGI states have submitted comments to the EPA welcoming "...the CPP's acceptance of multi-state and mass-based programs as a means of compliance with the EPA's proposed emission guidelines. RGGI has demonstrated that, by working together, groups of states can achieve greater emission reductions at a lower cost, all while creating jobs, maintaining grid reliability, and improving the regional economy".[226]

The flexibility provided by the EPA creates incentives for states join existing programs like RGGI, the program which implements the California's Global Warming Solutions Act (or AB32), the Pacific coast collaborative or form new regional alliances in the Midwest, Southeast and elsewhere. States do not need to be adjoining to set up joint programs. EPA should provide clear guidance to help enable states to take advantage of these opportunities, if they so choose.

The electricity system is already structured in a way that allows for multi-state compliance. States and regions should work with regional grid operators (including but not limited to ISOs and RTOs), who routinely coordinate on a regional basis the production and tracking of electric energy, as well as the fuel inputs and other costs. Grid operators have extensive experience with integrating new resources onto the grid and can help coordinate the changes necessary to bring on line cleaner resources like renewable energy and energy efficiency reliably and affordably.[227] The expansion of regional power grids such as PJM, Midcontinent ISO, and Southwest Power Pool has resulted in fossil fuel savings and related CO_2 reductions.[228] Their regional power plant coordination and use of grid connections between plants also smooth the integration of renewable energy. Furthermore, the Energy Imbalance Market (EIM), a new institutional approach to managing the regional grid operations of utilities in five western states, provides additional fuel savings, renewable energy integration, and associated emissions reductions.[229]

A recent study by PJM shows that it is much more cost-effective for the PJM power region to achieve compliance with the CPP at a regional level than it would be on a state-by-state basis.[230]

---

[226] RGGI. 2014. RGGI states' comments on proposed carbon pollution emission guidelines for existing stationary sources: electric utility generating units, 79 FR 34830. Online at http://www.rggi.org/docs/PressReleases/PR110714_CPP_Joint_Comments.pdf

[227] Union of Concerned Scientists (UCS). 2014. Renewable energy on regional power grids can help states meet federal carbon standards. Online at https://s3.amazonaws.com/ucs-documents/clean-energy/Renewables-Regional-Power-Grids.pdf.

[228] IRC. 2014. The EPA CO_2 Rule: ISO-RTO Council Reliability Safety Valve and Regional Compliance Measurement and Proposals. January 28. Online at http://www.isorto.org/Documents/Report/20140128_IRCProposal-ReliabilitySafetyValve-RegionalComplianceMeasurement_EPA-C02Rule.pdf.

[229] NREL. 2013. Examination of potential benefits of an energy imbalance market in the Western Interconnection. Golden, CO: National Renewable Energy Laboratory. Online at http://www.nrel.gov/docs/fy13osti/57115.pdf.

[230] PJM. 2014. The EPA's Clean Power Plan proposal: Review of PJM analyses preliminary results. Online at http://www.pjm.com/~/media/committees-groups/committees/mc/20141117-webinar/20141117-item-03-carbon-rule-analysis-presentation.ashx.

The study shows that load payments would be approximately $8 billion to 9 billion higher under a state-by-state approach as compared to a regional approach.

An additional opportunity for interstate collaboration exists through the implementation of the Federal Energy Regulatory Commission's (FERC's) Order 1000, which requires all public utility transmission providers to participate in a regional planning process.[231] They are required to consider the impacts of state and federal energy and environmental policies, such as renewable energy standards, state energy efficiency resource standards, and the CPP, on transmission system needs. Order 1000 creates a mechanism for neighboring states and regions to plan and pay for new transmission in a way that is mutually beneficial and can help ramp up wind and solar power and energy efficiency.

A number of states already participate in renewable energy trading systems to help meet their state RESs or other environmental goals.[232] The Clean Power Plan should leverage these existing tracking systems to provide greater flexibility to states to demonstrate compliance on a multi-state basis, while ensuring that there are safeguards in place to ensure accurate, common standards for emissions accounting (see section 6 above for more detail).

A strong Clean Power Plan, with ambitious and fair emission reduction targets, will itself create incentives for multi-state cooperation to meet those targets in a cost-effective manner. On the other hand, if the EPA sets weak targets that would dilute the incentive for states to join together. We agree with the RGGI states' comment that: "because the primary driver of interstate collaboration will be the need for significant emission reductions, revisions that affect parity will best support regional collaboration if they maintain or increase the total amount of emission reductions required nationally".[233]

9.3. UCS supports the inclusion of market-based approaches to demonstrate compliance and recommends that the EPA offer additional guidance on these options.

One option for market-based compliance for a single state or multiple states is to set up emissions trading programs, such as cap-and-trade programs. States could also choose to set a carbon tax or fee.[234] We support these types of option in states/regions that choose them, with the requirement that the emissions reductions from affected sources must be equivalent to that specified under the CPP, and that all emission reductions must come from the power sector (i.e., offsets from other sectors would not count toward compliance). There are considerable benefits to these types of approaches: They are cost-effective tools to meet the emissions reduction target; they create market incentives for investments in low-carbon energy; there is ease of tracking, monitoring, and reporting; these types of programs can raise carbon revenues that can help fund transition assistance for workers or energy bill assistance for low-income and fixed-income homeowners disproportionately affected by energy price increases. The cap-and-trade structure has been a demonstrated success in a number of cases, including RGGI, California's AB32 program, and the Acid Rain Program.[235]

---

[231] FERC. 2011. Order No. 1000. Final Rule on Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities.

[232] There are currently nine regional renewable energy certificate (REC) tracking systems in operation: the Texas Renewable Energy Credit Program (run by ERCOT, the NEPOOL-Generation Information System in New England, the PJM-Generation Attribute Tracking System (PJM-GATS), Western Renewable Energy Generation Information System (WREGIS), Midwest Renewable Energy Tracking System (M-RETS), North American Renewables Registry (NARR), Michigan Renewable Energy Certification System (MIRECS), Nevada Tracks Renewable Energy Credits (NVTREC) and the North Carolina Renewable Energy Tracking System (NC-RETS). The New York Generation Attribute Tracking System (NYGATS) is under development.

[233] RGGI. 2014. RGGI states' comments on proposed carbon pollution emission guidelines for existing stationary sources: electric utility generating units, 79 FR 34830. Online at http://www.rggi.org/docs/PressReleases/PR110714_CPP_Joint_Comments.pdf

[234] Wara, Michael W. and Morris, Adele C. and Darby, Marta, How the EPA Should Modify Its Proposed 111(D) Regulations to Allow States to Comply by Taxing Pollution (October 28, 2014). Stanford Public Law Working Paper No. 2516456; Stanford

Other innovative market-based options have also been offered by stakeholders, including a proposal by Great River Energy that would translate the state emission reduction targets to the regional power market level, meet the target by applying an ISO-administered carbon price to electric generation and refund the carbon revenues to load serving entities. The EPA should provide guidance on how these types of programs could demonstrate equivalence and compliance with the CPP.[236]

Additionally, some stakeholders have requested a model rule that lays out the details of an emissions trading program that would be considered compliant with the CPP. Since the EPA has now issued methodologies for calculating mass-based emission reduction targets for states, it should be relatively straightforward to provide this type of guidance. We recommend that the EPA provide guidance on elements of a model rule that would show states how to demonstrate equivalence for a market-based program and other criteria for compliance.

9.4. UCS recommends that the EPA provide guidance for the use of carbon revenues generated under market-based approaches.

Market based approaches create the opportunity to generate carbon revenues that can be used for transition assistance for displaced workers, help with energy bills for low income and fixed income households, investments in low carbon technologies targeted especially to Environmental Justice (EJ) communities, and other public interests. The EPA should provide guidance for those states that choose to use carbon revenue-raising programs to include these types of expenditures to compensate for the potential disproportionate impact of the CPP on these communities (see section 12 for recommendations on this issue).

Law and Economics Olin Working Paper No. 468. Available at SSRN: http://ssrn.com/abstract=2516456 or http://dx.doi.org/10.2139/ssrn.2516456.

[235] The Acid Rain Program, part of the 1990 Clean Air Act Amendments, limits emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x). The SO_2 reductions are being implemented via a cap on emissions combined with an allowance trading program. More information available at http://www.epa.gov/airmarkets/progsregs/arp/s02.html

[236] Chang, J., J. Weiss and Y. Yang. 2014. A Market-based Regional Approach to Valuing and Reducing GHG Emissions from Power Sector: An ISO-administered carbon price as a compliance option for the EPA's Existing Source Rule. A discussion paper prepared for Great River Energy by the Brattle Group. Online at http://www.brattle.com/system/news/pdfs/000/000/616/original/A_Market-based_Regional_Approach_to_Valuing_and_Reducing_GHG_Emissions_from_Power_Sector.pdf?1397501081.

For example, to date, the RGGI program has invested $700 million in energy efficiency, renewable energy and direct bill assistance programs that are projected to save more than $2 billion for 3 million households and 12,000 businesses in the Northeast (RGGI 2014).[237]

California's state budget for FY 2014–15 appropriates $832 million in auction proceeds for funding programs that will reduce GHG emissions, provide direct investments and benefits in disadvantaged communities, and provide additional environmental and economic co-benefits.[238]

9.5. UCS recommends that EPA require that multi-state compliance plans contain some key elements to ensure their robustness.

Multi-state compliance plans should include: an aggregated emissions reduction target that is equivalent to the combined emissions reductions that would accrue from the individual states' targets and otherwise meets the EPA guidance, a multi-state tracking and reporting system for emissions that meets standards set by the EPA, multi-state enforceability provisions (for example, if the combined group of states falls short of the target, then all states must cut emissions proportionally to ensure compliance), and a multi-state plan for ensuring adequate low-carbon resources, and the transmission to support them, is being planned, built and deployed.

Regional compliance will require translation of state rate-based targets or mass-based targets to multi-state targets to determine compliance on a regional/multi-state basis. The EPA's guidance to states on methods to convert rate-based targets to mass-based targets is a helpful step forward. More guidance will need to be provided to states to help them demonstrate equivalence and understand how multi-state compliance options would work across rate and mass-based boundaries.

Multi-state plans should include incentives for increasing renewable energy and energy efficiency, which can help lower the costs of reducing emissions. Where possible, these incentives should be targeted to EJ communities and communities where there is a need to diversify employment opportunities. Multi-state plans should also include incentives for reducing emissions as quickly as possible on a multi-state basis.

We support the recommendation that states that want to create multi-state compliance plans should be allowed additional time to submit them (up to a year extra, June 30, 2018, instead of June 30, 2017, as provided in the draft rule). The EPA's guidance for multi-state compliance plans should also include incentives for early action to encourage investments in renewables and energy efficiency and a shift away from fossil-fired generation after a state compliance plan has been approved by the EPA, as long as these incentives do not undermine the overall level of emissions reductions achieved by the CPP.

---

[237] The Regional Greenhouse Gas Initiative (RGGI). 2014. Regional Investment of RGGI CO_2 Allowance Proceeds, 2012. Feb. 2014. Online at http://www.rggi.org/docs/Documents/2012-Investment-Report.pdf.

[238] California Air Resources Board. N.d. Online at http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/budgetappropriations.htm.

10. Timing of Implementation and Compliance Dates for the Clean Power Plan

- **UCS supports the EPA's proposal for the implementation timeline of the Clean Power Plan, the deadlines for state and multi-state compliance plans, and the dates for compliance with interim and final state goals.**

- **UCS strongly recommends that the EPA review and update state goals and other aspects of the Clean Power Plan no later than 2025, to reflect technology improvements that can contribute to a BSER determination and opportunities for cost-effective emissions reductions.**

- **UCS does not support a change in the glide path for emissions reductions that would potentially delay emissions reductions.**

10.1. UCS supports the EPA's timeline for implementing the Clean Power Plan as fair.

The EPA's proposal provides fair and adequate time for states to devise compliance plans, and to meet their interim and final emission reduction goals. The proposal was announced on June 2, 2014 and is expected to be finalized in June 2015. States already have sufficient information to start work on their compliance plans, employing readily-available, commonsense measures to encourage low-carbon electricity generation. There is a 15-year period between the time the rule is expected to be finalized and its final compliance date, adequate time for the modest transition to cleaner generation sources required by the rule especially in light of the rapid market changes already underway that favor such a transition. The dramatically falling costs of renewable energy resources like wind and solar energy and the eroding economics of coal-fired power are among the reasons the CPP goals are eminently achievable and affordable.

The EPA has also proposed an optional two-phase process for state compliance plans, which we support. This approach allows for the requisite amount of certainty that states are making progress on their plans, while allowing for the time it may take for completing detailed analytic work to inform state plans, to pass or update legislation in support of state goals, and to coordinate with the diverse stakeholders needed to achieve a successful outcome. We agree with the requirement that states must file an initial plan by June 30, 2016, "that documents the reasons the state needs more time and includes commitments to concrete steps that will ensure that the state will submit a complete plan by June 30, 2017 or 2018, as appropriate." Further, we agree with the EPA's position that "To be approvable, the initial plan must include specific components, including a description of the plan approach, initial quantification of the level of emission performance that will be achieved in the plan, a commitment to maintain existing measures that limit CO_2 emissions, an explanation of the path to completion, and a summary of the state's response to any significant public comment on the approvability of the initial plan." A final state plan would then be due by June 30, 2017, or by June 30, 2018, in the case of a multi-state plan.

We agree that providing more time for multi-state compliance plans is reasonable. Multi-state approaches create greater flexibility and can help achieve emission reductions at a lower cost. Giving states additional time to coordinate could encourage more states to take this approach, driving greater benefits to all.

10.2. UCS does not support changing the trajectory of emissions reductions to weaken near-term targets, given that it would send the wrong market signal, and be contrary to climate goals.

In its October 28, 2014, Notice of Data Availability (NODA),[239] the EPA requested comment on a potential change in the "glide path" for emissions reductions that would make the 2020 interim state goals less stringent but keep the 2030 goals the same. In light of the many cost-effective, quickly-deployed options to cut emissions (including renewable energy and energy efficiency) and the urgent need to make deep cuts in our global warming emissions, UCS does not support any delay in achieving the emission reductions specified in the draft rule.

Delaying emissions reductions could also result in more stranded assets with utilities making investments to meet near-term targets that may be unsuitable for meeting the longer term targets.

We also strongly believe the EPA should strengthen both the interim and final emission reduction goals (see section 6 on the renewable energy building block for a specific proposal for how to do this). Doing so is technically and economically feasible, and also necessary to help limit global warming emissions. Furthermore, to meet the 2025 goal of a 26 to 28 percent reduction in net U.S. GHG emissions from 2005 levels, as agreed in the recent U.S.-China joint climate announcement, it will be necessary for the Clean Power Plan to be strong and deliver emission reductions in a timely way.[240]

10.3. UCS recommends that the EPA commit to reviewing and updating the Clean Power Plan by 2025.

The EPA should commit to reviewing and updating key aspects of the rule, including state goals and timelines, by 2025. The Clean Air Act requires the EPA to review New Source Performance Standards (NSPS) issued under Section 111 at least every eight years, and update standards at its discretion.[241] There are good reasons to anticipate that the BSER as currently established for existing power plants will be out-of-date by 2025, primarily because of the rapidly changing clean technology landscape (see below). Thus we strongly recommend that the EPA send a clear signal to states at the time of finalization of this rule that it is committed to this review and update process.

---

[239] Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units. Notice of Data Availability (NODA). 28 Oct 2014. 79 FR 64543. Online at https://www.federalregister.gov/articles/2014/10/30/2014-25845/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating.

[240] The White House. 2014. U.S.-China Joint Announcement on Climate Change and Clean Energy Cooperation. Fact sheet. Online at http://www.whitehouse.gov/the-press-office/2014/11/11/fact-sheet-us-china-joint-announcement-climate-change-and-clean-energy-c.

[241] Standards of performance for new stationary sources. 42 U.S.C. § 7411(b)(1)(B).

The electricity market is in a very dynamic period and we have seen tremendous changes just within the last five years in terms of the cost-competitiveness of cleaner generation sources. We expect that these changes will continue, especially with the incentives provided by the Clean Power Plan. It is critical that the CPP be updated by 2025 to take account of technological and market advances, with the aim of achieving even deeper emission reductions in 2030 and beyond.

By 2025, it is also likely that our scientific understanding of the risks of worsening climate impacts will have advanced, creating a greater demand for steep emissions reductions. By 2025, the EPA should also establish emission reduction targets for the post-2030 period, for at least 2035 and 2040, to signal the continued need to drive down emissions.

10.4. UCS supports the EPA's proposal for tracking of state compliance plan performance and true-up provisions, and recommends that the EPA require annual tracking and regular true-ups.

We support the EPA's proposal in the draft rule as excerpted below and further recommend that the EPA require states to undertake annual tracking of actual plan performance during implementation:

> *"In addition to demonstrating that projected plan performance will meet the interim and final state goals, the EPA proposes that state plans must contain requirements for tracking actual plan performance during implementation. For plans that do not include enforceable requirements for affected EGUs that ensure achievement of the full level of required emission performance and interim progress, the state plans would be required to include periodic program implementation milestones and emission performance checks, and include corrective measures to be implemented if mid-course corrections are necessary."*[242]

UCS also recommends that the EPA require that the state compliance plans include true-up provisions to ensure that they are on track to meet the interim and final compliance goals. This could take the form of true-ups, at least every 3 to 5 years, for the individual programs that contribute to state compliance goals, or an overall true-up of the achieved state emissions reductions. This type of regular review will help prevent situations where states fall short of the emission reduction goals and have to rapidly make up deficits. Policy and investment changes in the power sector require some time to implement or adjust, so advance notice will be key to ensuring they are well aligned with the goals of the Clean Power Plan.

One example of the importance of this type of review comes from the RGGI states, which, in 2012, undertook a program review of the CO_2 budget.[243] On the basis of changing market conditions, which showed a significant excess supply of allowances relative to actual emission levels in the region, the states chose to take advantage of the additional cost-effective emissions achievable and reduce the level of the carbon cap.

---

[242] Proposed Rule, 34905.

[243] RGGI. 2012 Program Review. Online at http://www.rggi.org/design/program-review.

We support the EPA's proposal that states provide Regular review of the performance of state implementation plans could provide important information to the EPA as it reviews and updates the whole Clean Power Plan prior to 2025, as mentioned above.

11. Need and Cost-effective Potential to Strengthen the Clean Power Plan

UCS recommends that the EPA ensure that the CPP achieves the full potential of cost-effective emissions reductions available in the power sector, and that these reductions take place in a timely manner, given the urgent need to cut global warming emissions. Strengthening the CPP is also a critical component of the US contribution to international efforts to cut global emissions and slow the pace of climate change.

UCS recommends, based on our analysis, that the EPA adopt several ways to cost-effectively strengthen the Clean Power Plan in keeping with the BSER criteria, including:

- **Increasing the contribution from the renewable energy and energy efficiency building blocks;**
- **Implementing a change in the goal computation formula to ensure that new and incremental renewable energy, energy efficiency, and nuclear generation explicitly replace generation from fossil fuel-fired sources, which is a better representation of the BSER and consistent with the treatment of incremental NGCC; simultaneously, we recommend a formula change to removing existing generation resources (renewable energy and "at risk" nuclear energy) from the denominator of the formula used to calculate state goals since the associated emission reductions are already embedded in the baseline emissions and generation mix.**
- **Including both the generation and emissions impacts of new NGCC units in the state goal calculation;**
- **Ensuring that there are no changes to the 2020-2029 glide path that result in a delay in the interim and final goals for emissions reductions achieved by the CPP.**

11.1. Increasing the contribution from renewable energy and energy efficiency.

As described in detail in section 6, UCS has developed an approach that builds on and improves the EPA's methodologies for calculating state renewable energy targets. The UCS Demonstrated Growth Approach uses the latest available market data, demonstrated rates of growth in renewable energy, and existing state commitments to deploy renewables. Using our recommended modifications, the EPA could nearly double the amount of cost-effective renewable energy in their state targets—from 12 percent of total 2030 U.S. electric sales to 23 percent. The EPA should adopt a similar approach.

Similarly, in section 8, we indicate our support for increasing the annual targets and ramp-up rates for energy efficiency deployment, based on current state and utility performance data and the range of policies and technologies that should be included in the EPA's assessments. UCS also recommends that the EPA update its cost and performance assumptions for efficiency and renewable energy technologies and measures to reflect current data and updated projections.

Our analysis shows that incorporating higher levels of renewable energy and energy efficiency in the state goals is both feasible and affordable. At the same time, this can provide a pathway to increase the overall emissions achieved by the standard. For example, we show that just by increasing the contribution from renewable energy, the standard would deliver emissions reductions of at least 40 percent below 2005 levels by 2030 instead of 30 percent as specified in the draft rule (see section 6 for more detail on our modeling results).

Separately, a June 2014 analysis by UCS shows that it is cost-effective to go even further by implementing a limit on carbon combined with energy efficiency and renewable energy policies. In that analysis we showed a cost-effective pathway to reduce US power sector emissions 60 percent below 2005 levels by 2030 through expanded use of renewable energy and energy efficiency.[244] Other studies have also shown that we can both reduce carbon emissions and lower electricity bills by deploying more energy efficiency and renewable energy through a combination of policies.[245,246,247]

11.2. UCS recommends that the EPA appropriately account for the emission reductions from displacement of fossil-fired generation sources by incremental renewable energy and energy efficiency.

We recommend that the EPA implement a change in the goal computation formula to ensure that incremental renewable energy and energy efficiency and nuclear generation explicitly replace generation from fossil fuel-fired sources on a pro-rata basis, which is a better representation of the BSER and consistent with the treatment on incremental NGCC. We support the alternative approach described in the NODA that establishes greater consistency across Building Blocks 2, 3 and 4, and results in greater CO_2 emissions reductions.

The EPA's formula for calculating state emissions goals does not account for the fossil-fired generation that would be displaced by incremental renewable energy, energy efficiency, and nuclear generation. We agree with stakeholders who, as described in the October 28 Notice of Data Availability,[248] have pointed out the discrepancy in the BSER formula for calculating state goals in the way that the emissions reductions attributable to Building Block 2 (re-dispatch to natural gas combined cycle) is calculated as compared to Building Blocks 3 and 4 (incremental renewables and efficiency).

---

[244] Cleetus, R., S. Clemmer, J. Deyette and S. Sattler. 2014. Climate game changer: How a carbon standard can cut power plant emissions in half by 2030. Online at http://blog.ucsusa.org/cut-power-plant-carbon-by-50-percent-new-epa-climate-rules-real-global-warming-solutions-552?_ga=1.7656945.2136133040.1407434157.

[245] Electric Power Research Institute (EPRI). 2010. The power to reduce CO_2 emissions. Palo Alto, CA. Online at www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001020142.

[246] Cleetus, R., S. Clemmer, and D. Friedman. 2009. Climate 2030: A national blueprint for a clean energy economy. Cambridge, MA: Union of Concerned Scientists. Online at ucsusa.org/global_warming/solutions/big_picture_solutions/climate-2030-blueprint.html.

[247] Energy Information Administration (EIA). 2009. Energy market and economic impacts of H.R. 2454, the American Clean Energy and Security Act of 2009. Washington, DC: U.S. Department of Energy. Online at www.eia.gov/oiaf/servicerpt/hr2454/.

[248] Environmental Protection Agency (EPA). 2014. Notice of Data Availability. 79 FR 64543, pages 64543 -64553. Online at https://federalregister.gov/a/2014-25845.

We agree with the description of the inconsistency in the treatment of Building Blocks 3 and 4, compared with building 2 detailed in the NODA:[249]

> *"The goal calculation for building block 2 not only reflects an increase in less carbon-intensive generation, but also applies an equal downward adjustment to each state's total existing fossil steam generation level in 2012, reflecting a generation shift away from higher-emitting fossil steam generation and toward lower-emitting NGCC generation. The result is that total generation is held constant, with only the mix of more and less carbon-intensive generation changing. In contrast, the approach in the proposal for incorporating building blocks 3 and 4 in the goal calculations does not reflect shifting generation away from fossil units because the total amount of generation is increased (including "megawatts" from EE as "generation") without any offsetting decrease in generation from 2012 fossil generation levels. By holding existing fossil generation at 2012 levels for purposes of goal calculation and estimating building blocks 3 and 4 independent of the interaction with those existing fossil generation levels, the state goals do not reflect the potential for added generation from building block 3 and avoided generation from building block 4 to shift generation away from existing fossil steam generation below the 2012 level and, therefore, do not reduce generation, and thus emissions, from affected fossil fuel-fired generation in keeping with the EPA's proposed approach to the BSER.*
>
> *"The formula in the draft rule simply adds incremental RE and EE to 2012 baseline generation levels (in the denominator of that formula) but does not reduce the 2012 baseline levels of fossil generation (in the denominator of the formula) by that incremental RE and EE, or remove the corresponding emissions (in the numerator of that formula)."*

As a solution, we recommend the alternative approach described in the NODA that establishes greater consistency in the treatment of Building Blocks 2, 3 and 4, and results in greater CO_2 emissions reductions. In the formula for goal computation, incremental renewable energy, energy efficiency, and nuclear generation should explicitly replace generation from fossil fuel-fired sources, which is a better representation of the BSER since it better reflects the likely reductions in fossil generation (and corresponding reduction in emissions) that can be achieved by affected sources.

We support the option in the NODA that would assume that incremental generation from Building Blocks 3 and 4 would directly replace 2012 fossil generation (i.e., fossil steam and gas turbine) and the corresponding emissions in proportion to their historical generation across generation types. Under the approach in the June 2014 proposal, incremental renewables and efficiency could replace a generation increase from existing fossil sources that would otherwise occur after 2012, while under this alternative approach, incremental renewables and efficiency could replace historical fossil generation below 2012 levels.

---

[249] Environmental Protection Agency (EPA). 2014. Notice of Data Availability. 79 FR 64543, pages 64543 -64553. Online at https://federalregister.gov/a/2014-25845.

Furthermore, if the EPA adopts a formula in which renewables and energy efficiency displace NGCC and coal-fired generation on a pro rata basis, it must also ensure that it corrects the potential emission reductions from building block 2. When renewables and energy efficiency displace NGCC generation, this will lower the capacity factor of NGCC plants and create additional potential reductions from building block 2. These additional reductions can be achieved either by displacing fossil generation from blocks 3 and 4 before calculating block 2 or by doing a true-up to block two to ensure that NGCC plants remain at a 70 percent capacity.[250]

11.3. UCS recommends that the EPA appropriately account for emissions changes from substituting existing fossil-fired generation with new natural gas generation.

The state goal computation formula in the draft proposal does not appropriately account for emissions resulting from substitution of existing fossil fired generation by new natural gas generation. In states where there is a significant increase in new NGCC generation, this could result in a significant increase in emissions that are not accounted for in state emissions goals. We recommend that this loophole be closed.

We agree with comments from AWEA on this issue (excerpted with small modifications below): If new natural gas plants are used for compliance purposes, they should be factored into the establishment of the targets to ensure symmetry between the resources considered in setting the target and resources allowed for compliance. Incorrectly treating new gas generators as if they have zero carbon emissions would result in less overall carbon emission reductions, as the actual emissions associated with operating the new gas generators would not be bound by the limit created by 111(d).[251] A failure to account for the emissions associated with new gas generators would effectively allow a state to treat new gas facilities as if they were zero-emission resources, skewing investment and dispatch decisions away from true zero-emission resources and even creating a strong distortionary incentive to substitute new gas generation for existing combined cycle generation in investment and dispatch decisions. The EPA should also periodically reevaluate, such as during the eight-year review process, to provide a mechanism for updating the fleet of facilities subject to the regulation in order to ensure that the 111(d) regulations continue to achieve significant emission reductions from fossil-fuel power plants, consistent with the no- backsliding policy.

---

[250] See comments from the Environmental Defense Fund and the Natural Resources Defense Council for further details on this issue.

[251] Note that new electricity generating units (EGUs), including new NGCC plants, are regulated under Section 111(b) of the Clean Air Act, and in September 2013 EPA issued a draft carbon standard for new power plants (available online at https://federalregister.gov/a/2013-28668).

11.4. UCS supports ensuring that the 2020-2029 glide path for state goals for emissions reductions remains as it is in the draft proposal and is not delayed in any way.

In the NODA, the EPA has solicited comment on changing the 2020-2029 glide path in a manner that would allow states to delay emissions reductions toward the end of that period, although the 2030 final goal would remain unchanged. We do not support this change to the glide path since the draft proposal already allows significant flexibility to states in the timing for reaching their interim goals. Further delays in achieving emissions reductions are contrary to the overall goals of the CPP to make a significant contribution to reduce US global warming emissions in a timely way. Nevertheless, if the EPA were to decide to make any change in the glide path, it should only be done in conjunction with strengthening the state emissions reduction goals required by CPP.

EPA has indicated that stakeholders have expressed particular concerns about the shift in generation by 2020 from the implementation of Building Block 2. Our analysis shows that the shift in generation away from coal-fired power is already under way for a variety of reasons including low natural gas prices, the cost-competitiveness of renewable energy and energy efficiency and health-based pollution standards.[252] As we point out in section 1, since 2009, utilities have announced plans to close or convert to natural gas more than 430 coal generators in 37 states. For many states this is already a significant portion of the switch away from coal to NGCC calculated in their Building Block 2 (see section 5). Many additional coal plants are economically vulnerable and should be considered for retirement. There are many cost effective options for replacing this generation with cleaner generation sources available in every region of the country (see section 6).

UCS does not support a phase-in of Building Block 2 because these trends are already underway and therefore already being phased in in the market place and states will have additional time to phase in changes prior to the first year of the interim goal compliance period (2020) and during the compliance period for interim goals of 2020-2029. We also do not agree with comments that states will face undue challenges from implementing this building block should they choose to use it. Furthermore, any state that does face constraints in implementing this building block has the flexibility to use other cost-effective building blocks to meet its overall interim and final targets.

Incentives for early action. UCS supports incentives for early action to encourage investments in renewables and energy efficiency and a shift away from fossil-fired generation after a state compliance plan has been approved by the EPA, as long as these incentives do not undermine the overall level of emissions reductions achieved by the CPP. The quicker we can cut emissions, the better from a climate perspective.

---

[252] Fleischman, L., R. Cleetus, J. Deyette, S. Clemmer, and S. Frenkel. 2013. Ripe for retirement: An economic analysis of the U.S. coal fleet. *The Electricity Journal* 26(10):51-63. Online at dx.doi.org/10.1016/j.tej.2013.11.005.

11.5. UCS recommends that the EPA remove existing generation resources (renewable energy and nuclear energy) from the denominator of the formula used to calculate state goals.

The EPA's adjusted emissions rate formula includes existing renewable energy generation and 6% "at risk" nuclear generation in the denominator of the formula used to calculate state emission reduction goals. This results in a formula that is not truly measuring the emissions rate reduction. Removing these components from the formula would result in a goal that is a better representation of the BSER and would also result in a more consistent treatment of all zero-carbon emitting generation sources.

11.6. UCS recommends that the EPA strengthen the CPP as a critical component of the U.S. contribution to international climate efforts.

The next year, leading up to the United Nations Framework Convention on Climate Change (UNFCCC) negotiations in Paris in December 2015, is a critical one for reaching a fair and ambitious global climate agreement. On November 11, 2014, President Obama and President Xi Jinping of China made a historic joint announcement committing both countries to serious steps to lower their emissions.[253] The U.S. has set a goal of a 26 to 28 percent cut in its net GHG emissions by 2030, while China intends to reach a peak in its CO_2 emissions by 2030 and has signaled that its use of coal will peak in 2020 at 4.2 billion tons.[254] China also plans to increase the share of non-fossil fuels in primary energy consumption to around 20 percent by 2030. This agreement between the two major emitting nations represents a significant breakthrough and can help unlock equivalent actions by other nations in the lead-up to the Paris meeting.

Strengthening the CPP is critical to reaching the upper end of the current U.S. offer of a 28 percent reduction in emissions from 2005 levels by 2030. Analysis by UCS and other experts shows that there are many near-term, cost-effective options to cut power sector emissions, which are a major portion of total U.S. emissions. [255] Furthermore, in our judgment, the US offer can and should be more ambitious in light of the many affordable opportunities to further reduce emissions, and the grave threat posed by climate change. If the CPP is strengthened in the ways we have described in sections 11.1 to 11.5, we estimate that it would be possible, in conjunction with CO_2 emission reductions in other sectors and in non-CO_2 global warming emissions, to raise the US offer. Ambitious reductions in carbon emissions are critical if we are to limit the impacts of climate change. The current rate of rising global CO_2 emissions is cause for great concern. The IPCC Fifth Assessment Synthesis Report states that:

---

[253] The White House. 2014. U.S.-China Joint Announcement on Climate Change. Washington DC: Office of the Press Secretary. Online at http://www.whitehouse.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change

[254] The State Council of China. 2014. Energy Development Strategy Action Plan (2014-2020). Online at http://news.xinhuanet.com/english/china/2014-11/19/c_133801014.htm

[255] Williams, J.H., B. Haley, F. Kahrl, J. Moore, A.D. Jones, M.S. Torn, H. McJeon. 2014. Pathways to deep decarbonization in the United States. The U.S. report of the Deep Decarbonization Pathways Project of the Sustainable Development Solutions Network and the Institute for Sustainable Development and International Relations. Online at https://ethree.com/publications/index_US2050.php.

Clemmer, S., J. Rogers, S. Satttler, J. Macknick, and T. Mai. 2013. Modeling low-carbon US electricity futures to explore impacts on national and regional water use. Environmental Research Letters 8; doi:10.1088/1748-9326/8/1/015004.

Cleetus, R., S. Clemmer, and D. Friedman. 2009. Climate 2030: A National Blueprint for a Clean Energy Economy. Cambridge, MA: Union of Concerned Scientists. Online at http://www.ucsusa.org/global_warming/solutions/big_picture_solutions/climate-2030-blueprint.html.

Fawcett A.A., V.C. Katherine, F.C. de la Chesnaye, J.M. Reilly, and J.P. Weyant. 2009. Overview of EMF 22 US transition scenarios. Energy Economics 3:S198–211.

> *"...limiting total human-induced warming to less than 2°C relative to the period 1861-1880 with a probability of >66% would require cumulative CO_2 emissions from all anthropogenic sources since 1870 to remain below about 2900 $GtCO_2$ (with a range of 2550-3150 $GtCO_2$ depending on non-CO_2 drivers). About 1900 $GtCO_2$ had already been emitted by 2011."*[256]

The stark math of that limited carbon budget makes clear that, ultimately, we will need to cut emissions much more than what may be possible under the Clean Power Plan, but a strong CPP is a critical step along that path.

---

[256] IPCC. 2014. Fifth Assessment Synthesis Report. Online at http://ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_LONGERREPORT.pdf.

12. Environmental and Economic Justice Concerns

- **UCS recognizes that, unless state compliance plans include specific worker transition provisions, the proposed standard for carbon emissions at existing power plants may have disproportionately negative impacts among certain coal-heavy geographic regions, coal-dependent communities, and coal-related workers.**

- **UCS recommends that the EPA work in conjunction with other federal and state agencies to leverage existing programs and resources that can be brought to bear in addressing impacts to coal communities and assisting displaced workers. States should consider a variety of policy mechanisms, both within the context of state compliance plans and through complementary policies enacted by state legislatures, to address these needs.**

- **UCS recommends that EPA require states to conduct environmental justice analyses of their compliance plans, and provide guidance to states on how to assess changes in criteria pollutants, water quality, and other environmental damage that may result from their compliance plans and assess the potential impacts on neighboring or downwind communities.**[257]

- **UCS recommends that states prioritize the development of renewable energy resources and the expansion of energy efficiency programs in overburdened and impacted communities, including low-income, minority, disadvantaged, and coal-heavy populations.**

The EPA and states must pay particular attention to both environmental and economic justice issues. Overburdened communities, including low-income and minority populations, often face the greatest impacts from criteria air pollutants; conversely, coal workers may face the loss of their livelihoods in the transition to a clean energy economy. The impacts of climate change will disproportionately affect certain communities, such as the poor, the elderly, and the very young, who are most vulnerable to health impacts, as well as minority and disadvantaged communities, which notably already face significantly greater health impacts due to poor air quality. Similarly, without foresight and planning, policies to address the threat of climate change could negatively impact communities that depend on fossil-related industries for economic activity and jobs.

In its proposal, the EPA outlined specific elements of an approvable state compliance plan. Given the complex nature of the proposed standard, the agency should specify a menu of options that states could use to address both environmental and economic justice concerns. State compliance plans should direct resources to the most impacted communities, while reducing emissions, protecting workers, and mitigating direct health impacts. Shutting down old, inefficient, and polluting coal plants[258] can help reduce health impacts in overburdened communities[259] while investments in renewable energy and energy efficiency can help create jobs and strengthen local economies, which is of critical importance to communities heavily reliant on coal and related industries.

---

[257] For example, the EPA should integrate the technical guidance in Plan EJ 2014 into its guidance for state compliance plans for the CPP to help states comply with the requirement for an environmental justice analysis of those plans. (EPA. N.d. Plan EJ 2014. Online at http://www.epa.gov/environmentaljustice/plan-ej/)

Economic Justice: Job Creation and Worker Transition

12.1. UCS recommends that the EPA emphasize—and provide guidance to states on—the potential for job creation and economic development from investments in renewable energy and energy efficiency and in supporting industries, especially manufacturing.

With the rapid decline in cost and corresponding increase in deployment of renewable energy resources like wind[260] and solar,[261] fossil generation is under increasing competition from cleaner alternatives for electricity. The proposed standard for carbon emissions represents an opportunity for states to amplify or jumpstart investments in both renewables and efficiency and to stimulate local economies. Many studies have demonstrated the job growth and economic benefits of such investments. Most recently, a report looking at California as a case study[262] demonstrates how federal, state, and construction industry policies have led to the development of nearly 5000 MW and the creation of more than 15,000 jobs.[263] Thanks to strong labor agreements, not only are workers well-paid and receive solid health and pension benefits, but also contractors have contributed $17.5 million for training programs. Solar development in California "is preparing a new generation of California blue collar workers for a future of skilled and productive work and a life of financial security."[264]

12.2. UCS recommends that the EPA require that states assess impacts of their compliance plans on workers and communities that will be disproportionately affected.

In its Regulatory Impact Analysis (RIA), the agency projects that the standard would cause total U.S. coal production to fall by 25 to 27 percent in 2020[265] (and from 35 to 37 percent in the Appalachian region) and that employment in coal extraction would decline by 13,700 to 14,300 job years annually by 2020.[266] Importantly, however, the future of the coal industry, even without this rule, is uncertain at best,[267] and it has already declined, particularly in Central Appalachia,[268] due to cheap and abundant natural gas, competition with other coal mining regions, decreasing labor productivity (and increasing costs), and earlier environmental regulations. Although the RIA concludes that the proposed standard likely will result in an increase in net jobs nationally, it must be recognized that job impacts will be unevenly dispersed—some regions and states will be winners, and others will experience economic consequences from a shift away from coal. Although the agency has no authority under the CAA to provide assistance to states facing negative impacts, it can and should offer guidance to those states on ways to help to address such concerns. Coal-heavy states, in turn, should consider using compliance plans to help diversify their economies.

---

[258] Cleetus, R., S. Clemmer, E. Davis, J. Deyette, J. Downing, and S. Frenkel. 2012. Ripe for retirement: The case for closing America's costliest coal plants. Cambridge, MA: Union of Concerned Scientists, November 2012. Online at http://www.ucsusa.org/assets/documents/clean_energy/Ripe-for-Retirement-Full-Report.pdf.

[259] Wilson, A. et al. 2012. Coal blooded: Putting people before profits. Online at http://www.naacp.org/page/-/Climate/CoalBlooded.pdf.

[260] American Wind Energy Association (AWEA). 2014. U.S. wind industry annual market report 2013. Washington, DC: AWEA.

[261] Solar Energy Industries Association (SEIA). 2014. Solar energy facts: 2013 year in review. Washington, DC: SEIA. Online at www.seia.org/sites/default/files/YIR%202013%20SMI%20Fact%20Sheet.pdf, accessed on September 15, 2014.

[262] Philips, P. 2014. Environmental and economic benefits of building solar in California. Donald Vial Center on Employment in the Green Economy. Institute for Research on Labor and Employment, UC Berkeley. Online at http://laborcenter.berkeley.edu/environmental-and-economic-benefits-of-building-solar-in-california-quality-careers-cleaner-lives/.

[263] Includes 10,200 construction jobs, 136 permanent O&M jobs, and over 3,700 additional jobs (induced).

[264] Philips 2014.

[265] Table 3.15, Regulatory Impact Analysis.

12.3. UCS recommends that the EPA highlight—provide guidance to states on considering—a variety of policy mechanisms, both within the context of state compliance plans and through complementary policies enacted by state legislatures, to retrain workers and invest in economic diversification.

Many such policies have the potential to generate revenue that the state can then invest as they see fit. Policies could include:

- **Market-Based Mechanisms.** The Regional Greenhouse Gas Initiative (RGGI) offers an example of how state collaboration on market-based solutions could generate revenue for states as they lower carbon emissions. For example, in 2012 RGGI states invested 73 percent of auction revenue in energy efficiency programs, which is expected to save participants $1.8 billion on electricity bills over the lifetime of the measures.[269] During the first compliance period from 2009-2012, RGGI auctions generated $912 million in proceeds and produced $1.6 billion in net present value to the (then) ten-state region, corresponding to almost $33 per capita spread throughout the region.[270] Cumulatively, from 2009-2012, 65 percent of proceeds went to energy efficiency, 17 percent to direct bill assistance, 6 percent to clean and renewable energy, and 6 percent to GHG abatement—but states direct their own auction revenue as they see fit. Coal-heavy states that join regional programs could decide to direct auction revenue to worker retraining and economic diversification, and should be encouraged to do so. California's AB 32 similarly sets up a market-based mechanism for reducing emissions that generates revenue for the state (see below).

---

[266] Tables 6.4 and 6.5, Regulatory Impact Analysis.

[267] Richardson, L. J., R. Cleetus, S. Clemmer, and J. Deyette. 2014. Economic impacts on West Virginia from projected future coal production and implications for policymakers. Environmental Research Letters, 18 Feb 2014. 9(2): 024006. doi:10.1088/1748-9326/9/2/024006.

[268] McIlmoil, R., E. Hansen, N. Askins, and M. Betcher. 2013. The continuing decline in demand for Central Appalachian coal: Market and regulatory influences. Downstream Strategies, 2013. Online at http://www.downstreamstrategies.com/documents/reports_publication/the-continuing-decline-in-demand-for-capp-coal.pdf.

[269] RGGI 2014. Regional Investment of RGGI CO_2 Allowance Proceeds, 2012.

[270] Hibbard et al. 2011. The economic impacts of the Regional Greenhouse Gas Initiative on ten Northeast and Mid-Atlantic states. The Analysis Group.

- **Carbon Fees.** Sub-national governments have enacted prices on carbon emissions. British Columbia, for example, enacted a carbon tax[271] in 2008; the revenue neutral program in fiscal year 2013-14 is expected to generate $1.2 billion in proceeds to offset other taxes. Such policies can be used to generate revenue that could be directed to affected workers and communities. The EPA should explicitly identify carbon fees that drive down emissions as an allowable state compliance mechanism[272] (see section 9).

- **Permanent Mineral Trust Funds.** Many resource-rich states have enacted permanent mineral trust funds, which levy a special tax on companies for right to remove resources from the ground.[273] Wyoming, for example, enacted its program in 1974, and as of 2013, the fund was worth $5.88 billion.[274] In March 2014, West Virginia established the Future Fund,[275] similarly designed to direct a fraction of severance tax revenue from mineral resources (notably, including coal) to economic diversification and development focusing on regions where the extraction takes place. Although no revenue is currently being directed toward the Future Fund due to other budget priorities, the legislation specifically allows for other sources of revenue to be deposited into the fund.

- **Renewable Electricity Standards.** In addition to helping states meet their carbon reduction goals, RES policies[276] can spur renewable development. Some states have even defined their RESs to designate a portion of RE development from in-state resources to support local job creation. Studies find limited cost impacts from such policies, and some states have quantified measurable economic benefits from the programs.[277]

- **Energy Efficiency Resource Standards.** Similarly, policies that promote energy efficiency in homes and businesses can not only help states meet the EPA targets, but also create local jobs that cannot be outsourced, while saving consumers money on their electricity bills.[278]

- **Worker Training Programs.**

- **Economic Development and Economic Diversification.**

---

[271] http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm.

[272] Wara, M., W. Adele, C. Morris, and M. Darby. 2014. How the EPA should modify its proposed 111(d) regulations to allow states to comply by taxing pollution. SSRN 2014. Online at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2516456.

[273] Boettner T., J. Kriesky, R. McIlmoil, and E. Paulhus. 2012. Creating an economic diversification trust fund: Turning nonrenewable natural resources into sustainable wealth for West Virginia. West Virginia Center on Budget and Policy, January 2012. Online at http://www.wvpolicy.org/downloads/WVEconomicDiversificationTrustFundRpt013012.pdf.

[274] Gordon, M. 2013. Wyoming State Treasurer Annual Report for the Period July 1, 2012 through June 30, 2013. Online at http://treasurer.state.wy.us/pdf/annualweb2013.pdf.

[275] Bill Text, as passed, March 10, 2014: http://www.legis.state.wv.us/Bill_Status/Bills_history.cfm?input=461&year=2014&sessiontype=RS&btype=bill.

[276] See Lawrence Berkeley National Laboratory, http://emp.lbl.gov/rps.

[277] Heeter, J., G. Barbose, L. Bird, S. Weaver, F. Flores-Espino, K. Kuskova-Burns, and R. Wiser. 2014. A survey of state-level cost and benefit estimates of Renewable Portfolio Standards. Online at http://www.ourenergypolicy.org/wp-content/uploads/2014/06/nrel.pdf.

[278] Alliance to Save Energy. 2013. Energy Efficiency Resource Standard. Online at https://www.ase.org/sites/ase.org/files/resources/Media%20browser/eers_fact_sheet_9-13.pdf.

12.4. UCS recommends that the EPA engage with other federal agencies on addressing worker transition concerns.

Recognizing that the proposed standard may disproportionately impact coal communities, the agency should work in conjunction with other federal agencies to leverage existing programs to support displaced workers. The federal government already has a number of programs to support worker retraining and community development, all of which are currently funded and not reliant on further action from Congress. In particular, the Department of Agriculture's Rural Development program, the Department of Commerce's Economic Development Administration, the Department of Labor's Economic Training Administration, and the Appalachian Regional Commission all have programs in place to support workers and communities. By leveraging existing authority, the federal government can direct targeted resources to affected communities and help coal states diversify their economies. For example, the Obama Administration designated southeastern Kentucky as a federal Promise Zone[279] to focus on poverty alleviation by establishing a partnership between federal agencies and local institutions. Together, federal agencies should work with Congress to develop targeted legislation to address displaced workers in coal mining, coal fired power plants, and related industries. Numerous examples in recent history serve as a roadmap for successful worker retraining programs, including the Trade Adjustment Act and the Workforce Reinvestment Act. More recently, a bipartisan bill was introduced in the 113th Congress specifically directed at coal workers.[280]

12.5. UCS recommends that the EPA work with stakeholders to help protect workers as the rule is implemented.

With foresight and planning, states can develop implementation plans that lead to net job creation nationally. As the BlueGreen Alliance[281] emphasizes, it is critical to provide direct support to workers and communities—extending to ancillary and support sectors as well as the utility sector—if and when a power plant shuts down, by providing wages, benefits, training, education, and the recognition of basic workers' rights. Communities will need resources to diversify their economies and create high-paying jobs that can match or exceed those that may have been lost. The private sector, including utilities, and all levels of government must work in tandem with communities to make these transitions a success. Regulated entities should not be allowed to skirt commitments made to workers—as power plants and coal mines close or idle, owners should honor the commitments they made to workers, including pensions and health benefits.

---

[279] http://www.nytimes.com/2014/01/10/us/politics/obama-announces-promise-zones-in-5-stricken-areas.html.

[280] http://blogs.rollcall.com/218/in-a-partisan-climate-two-lawmakers-try-to-talk-past-climate-change/.

[281] http://www.bluegreenalliance.org/news/publications/testimony-of-the-bluegreen-alliance-at-public-hearing-on-EPAs-clean-power-plan.

Environmental Justice and Overburdened Communities

12.6. UCS recommends that the EPA require states to conduct an environmental justice analysis of their compliance plans.

Executive Order 12898[282] requires federal agencies to "identify and address the disproportionately high and adverse human health or environmental effects of their actions on minority and low-income populations, to the greatest extent practicable and permitted by law."[283] The agency considered the negative impacts on vulnerable communities of greater utilization of certain EGUs.[284] The EPA determined that it is "not practicable" to conduct a detailed analysis of environmental justice impacts of the proposed rule, due to the nature of the electricity grid and uncertainty surrounding which plants would operate more or less frequently or close altogether. This implies that states, especially if working in the context of regional agreements, would be better positioned to conduct an environmental justice analysis of the impacts of their compliance plans. In doing so, states must assess the impacts of the changes in utilization rate of specific plants on criteria pollutants on overburdened communities, both surrounding and downwind of the plant. In implementing the rule, states should take steps to ensure that polluting facilities are not provided incentives for operating more frequently and therefore exacerbating pollution "hot spots" in low-income and minority communities.

12.7. UCS recommends that the EPA offer states data, methodology, and tools to conduct effective EJ analyses.

The EPA is engaged in a process to integrate environmental justice into is programs, policies, and activities. Called Plan EJ 2014, the agency finalized its overarching EJ strategy in 2011 after public input on key issues of overburdened communities. Under Plan EJ 2014, the agency is currently finalizing technical guidance for assessing environmental justice in regulatory analyses.[285] EPA should integrate this technical guidance in Plan EJ 2014 into the guidance document it issues for state compliance plans for the CPP to help states comply with the requirement for an environmental justice analysis of its compliance strategy.[286]The implementation of California's AB 32 (Global Warming Solutions Act) and follow-up bill (SB 535) also provide important examples of how to address EJ concerns.[287]

12.8. UCS supports prioritizing the development of renewable energy and energy efficiency in overburdened communities as part of state compliance plans.

The EPA should offer examples to states of how compliance plans could be used to support these communities, particularly through revenue streams. Both California and RGGI offer examples of how to invest revenue to support low-income communities. Some funds from these revenues should be rebated to overburdened communities. In addition to direct bill assistance,[288] RGGI states have channeled auction revenue specifically to low-income households; Delaware, for example, has invested approximately 21 percent of its cumulative-to-date auction revenue into low-income home weatherization and heating assistance.[289] Development of community scale renewables, energy efficiency investments, net metering policies, and local hiring provisions can support building a green economy in disadvantaged communities.[290] States could also fund weatherization programs and leverage federal Department of Energy funding for these activities.

---

[282] 59 FR 7629, February 16, 1994.

[283] http://www2.epa.gov/laws-regulations/summary-executive-order-12898-federal-actions-address-environmental-justice.

[284] https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating#p-1445.

[285] http://epa.gov/environmentaljustice/resources/policy/plan-ej-2014/plan-ej-progress-report-2014.pdf.

[286] EPA. N.d. Plan EJ 2014. Online at http://www.epa.gov/environmentaljustice/plan-ej/.

[287] Truong, V. 2014. Addressing Poverty and Pollution: California's SB 535 Greenhouse Gas Reduction Fund. Harv. CR-CLL Rev. 49 (2014): 493–569.

12.9. UCS recommends that the EPA encourage states to solicit input on state compliance plans from a wide variety of stakeholders.

Outreach efforts should include robust and extensive dialogues with community leaders and the public, with particular attention to EJ communities.[291]

---

[288] Cumulatively, RGGI states have invested 17 percent of auction revenue in direct bill assistance.

[289] http://www.rggi.org/rggi_benefits/program_investments/delaware.

[290] Patterson, J. et al. 2014. Just Energy Policies: Reducing Pollution and Creating Jobs. Online at http://www.naacp.org/pages/just-energy-policies-report.

[291] We recommend that the EPA solicit feedback and participation from EJ groups like WE ACT and National Environmental Justice Advisory Council (NEJAC) to help formulate guidance on including EJ concerns in state compliance plans.

13. Guidance to States

UCS recommends that the EPA provide clear guidance to states in developing their compliance plans to ensure that states are able to develop and submit robust plans in a timely way, and that such guidance cover issues such as treatment of certain energy options, best practices, methodologies, non-compliance penalties, processes, and options for addressing worker transition and environmental justice concerns.

Clear guidance to states from the EPA will help ensure that compliance plans are robust and timely. The Clean Power Plan's flexibility provides many cost-effective options for states to reduce emissions. At the same time, there are some complex issues raised by the interaction of these options, and the need to ensure states are on track to achieve emissions reduction goals. The EPA should provide clarity on some key issues mentioned below, many of which were raised in stakeholder comments and the NODA.

UCS recommends in particular that the EPA provide guidance on, for example:

- **Treatment of new natural gas combined cycle (NGCC) plants.** As discussed in section 11.3 above, in the final rule the EPA should provide clear guidance to states on how to treat new NGCC plants, both in the state emissions rate formula and for compliance purposes. UCS recommends that, if new NGCC plants are used for compliance, it will be important to ensure that the resulting emissions are appropriately accounted for.

- **Treatment of out-of-state renewable energy generation.** As discussed in section 6 above, renewable energy will be a key component of state compliance plans and the EPA should provide clear guidance on how states should track and account for renewable energy that is traded across state boundaries. UCS recommends that the EPA clarify for states how they should treat out-of-state renewable energy generation for compliance plan purposes to encourage development of cost-effective renewable energy resources nationwide, avoid double-counting, and ensure synchronization with existing energy trading and tracking systems.

- **Evaluation, measurement, and verification (EM&V).** Robust protocols for EM&V for electricity generation, energy efficiency, and other components of state compliance plans must guard against double-counting to provide for robust emissions accounting across all building blocks. UCS recommends that the EPA provide states "best practices" and sample methodologies for conducting EM&V with regard to these issues, and provide certification protocols for methodologies developed by other parties.

- **Criteria for enforceability.** State compliance plans that incorporate state programs must contain federally enforceable components to ensure that the emissions reduction goals are met. UCS recommends that the EPA provide clear guidance to states on incorporation of such components for demonstrating compliance.

- **Multi-state or regional compliance.** As discussed in section 9 above, multi-state or regional strategies may be attractive to states as the least-cost compliance option. UCS recommends that the EPA provide robust methodologies for demonstrating compliance under such multi-state approaches.

- **Market-based approaches.** As discussed in section 3.8 above, states may also choose market-based approaches as a least-cost compliance option. UCS recommends that the EPA provide robust methodologies for demonstrating compliance under such market-based approaches.

- **Equivalence of state/regional programs.** States may incorporate existing or new state or regional programs into their compliance plans. UCS recommends that the EPA provide states with clear methodologies for determining the equivalence of the emissions reductions achieved by such programs with the requirements of the CPP.

- **Rate-to mass-based conversions.** In a November 6 Technical Support Document (TSD), the EPA provided guidance for states on converting between emission rate- and mass-based goals.[292] UCS recommends that the EPA provide further clarification on key considerations for such conversions, especially if the EPA implements any changes to the formula for calculating state emissions rate goals in the draft CPP.

- **Penalties for non-compliance.** Penalties for non-compliance will be an important component of a successful CPP. UCS recommends that the EPA provide clear guidance to states about penalties.

- **State compliance plan tracking.** As discussed in section 10.4 above, UCS supports the EPA's proposal in the draft rule with regard to state plan compliance tracking, and recommends that the EPA require states to undertake annual tracking of actual plan performance during implementation, and that the EPA require state compliance plans to include true-up provisions to ensure that they are on track to meet the interim and final compliance goals.

- **Review and updating process for the CPP**. As discussed in section 10.3 above, UCS recommends that the EPA provide clear guidance to states about the timing of future updates to the CPP, and ensure that a review and update process takes place by 2025.

- **Worker transition assistance.** As discussed in section 12 above, compliance with the CPP may cause localized negative economic impacts. UCS recommends that the EPA offer guidance to states on ways to address concerns about such impacts, require that states assess impacts of their compliance plans on workers and communities, and highlight for states a variety of policy mechanisms for worker retraining and economic diversification.

---

[292] EPA. 2014. Notice of additional information regarding the translation of emission rate-based CO2 goals to mass-based equivalents. 79 FR 67406. Online at https://federalregister.gov/a/2014-26900.

- **Environmental justice (EJ).** As discussed in section 12 above, UCS recommends that the EPA require states to conduct an EJ analysis of the state's proposed compliance plan, offer states data, methodology, and tools to conduct effective EJ analyses; and offer examples of how compliance plans could be used to support EJ communities.

Appendix 1. ReEDS Methodology

Methodology and assumptions for UCS modeling of strengthening the EPA's Clean Power Plan: Increasing renewable energy use will achieve greater emission reductions.

UCS used the National Renewable Energy Laboratory's (NREL) Regional Energy Deployment System (ReEDS) model to analyze the technical and economic feasibility of adopting higher renewable energy targets under the Environmental Protections Agency's (EPA) proposed Clean Power Plan (CPP). This document describes the methodology and assumptions that were used for that analysis. The ReEDS modeling of the UCS proposed "Demonstrated Growth Approach" shows that doubling EPA's 2030 renewable energy target from 12 percent to 23 percent of U.S. electricity sales by 2030 is affordable and would increase the total emissions reductions achieved by the CPP from 30 percent to approximately 40 percent below 2005 levels by 2030 (UCS 2014).

ReEDS is a computer-based, long-term capacity-expansion model for the deployment of electric power generation technologies in the United States. ReEDS is designed to analyze the impacts of state and federal energy policies, such as clean energy and renewable energy standards or reducing carbon emissions, in the U.S. electricity sector. ReEDS provides a detailed representation of electricity generation and transmission systems and specifically addresses issues related to renewable energy technologies, such as transmission, resource quality, variability, and reliability. UCS used the 2014 version of ReEDS for our analysis. However, we did make some changes to NREL's assumptions for renewable and conventional energy technologies based on project-specific data and mid-range estimates from recent studies, as described in more detail below.

Scenarios

To analyze the impacts of adopting higher state renewable energy targets under the CPP, we compared the UCS Demonstrated Growth Approach to a Business as Usual (BAU) scenario. The BAU scenario assumes no new state or federal policies beyond those which existed at the end of 2013. This scenario establishes a baseline for the analysis using project-specific technology cost and performance assumptions benchmarked to recent studies.

UCS's Demonstrated Growth Approach analyzes the impacts of stronger state renewable energy targets than those proposed in EPA's draft Clean Power Plan. As a proxy for the draft rule, we focused on the renewable energy building block and modeled impacts of achieving the state targets aggregated up to the national level, which ramped up to 23 percent of electricity sales coming from renewable energy nationally in 2030. We also assumed unrestricted national trading of renewable energy credits, which would allow states to meet their targets at the lowest costs. If there are any policy constraints placed on trading between regions, experience with renewable energy markets suggest REC prices will likely be higher in some regions and lower in other regions of the country.[293]

Assumptions

The cost and performance assumptions for electric generating technologies that UCS used in the 2014 version of NREL's Regional Energy Deployment System (ReEDS) are shown in Tables A1.1-A1.3 below, compared to EIA's AEO 2014 assumptions (EIA 2014). We also describe our assumptions for energy efficiency investments that were not included in the model. For conventional technologies, NREL uses EIA's AEO 2014 cost and performance assumptions. We did not make any changes to EIA's assumptions for natural gas and coal prices, fixed and variable O&M costs, and heat rates, with a few exceptions noted below (EIA 2014). However, we did make several changes to EIA's capital cost assumptions and wind and solar capacity factors based on project specific data for recently installed and proposed projects, supplemented with estimates from recent studies, when project data was limited or unavailable. The cost and performance assumptions for renewable energy technologies are mostly consistent with the assumptions that were developed for the forthcoming DOE Wind Vision report (DOE 2014). These changes we made include:

- **Learning**. We do not use EIA's learning assumptions that lower the capital costs of different technologies over time as the penetration of these technologies increase in the U.S. (EIA 2014). This approach does not adequately capture growth in international markets and potential technology improvements from research and development (R&D) that are important drivers for cost reductions. Instead, we assume costs for mature technologies stay fixed over time and we hard wire cost reductions for emerging technologies.

- **Natural gas and coal.** For plants without carbon capture and storage (CCS), we use EIA's initial capital costs, but do not include EIA's projected cost reductions due to learning because we assume they are mature technologies. For new IGCC and supercritical pulverized coal plants, we use EIA's higher costs for a single unit plant (600-650 MW) instead of dual unit plants (1200-1300 MW), which is more consistent with data from proposed and recently built projects (SNL 2013). For plants with CCS, we assume: 1) higher initial capital costs than EIA based on mid-range estimates from recent studies (Black & Veatch 2012, Lazard 2013, NREL 2012, EIA 2014), 2) no cost reductions through 2020 as very few plants will be operating by then, and 3) EIA's projected cost reductions by 2040 will be achieved by 2050 (on a percentage basis).

- **Nuclear.** We assume higher initial capital costs than EIA for new plants based on mid-range estimates from recent studies and announced cost increases at projects in the U.S.

---

[293] For more details on the UCS approach and the modeling results, see UCS. 2014. Strengthening the EPA's Clean Power Plan: Increasing renewable energy use will achieve greater emission reductions. Online at http://www.ucsusa.org/sites/default/files/attach/2014/10/Strengthening-the-EPA-Clean-Power-Plan.pdf.

that are proposed or under construction (Black & Veatch 2012, Henry 2013, Lazard 2013, Penn 2012, SNL 2013, Vukmanovic 2012, Wald 2012). We did not include EIA's projected capital cost reductions, given the historical and recent experience of cost increases in the U.S. We also assume existing plants will receive a 20-year license extension, allowing them to operate for 60 years and will then be retired due to safety and economic issues. In addition, we include 4.7 GW of retirements at five existing plants (Vermont Yankee, Kewaunee, Crystal River, San Onofre, Oyster Creek) based on recent announcements and closures, and 5.5 GW of planned additions (Vogtle, V.C. Summer, and Watts Bar).

- **Onshore Wind**. We assume lower initial capital costs than EIA based on data from a large sample of recent projects from DOE's *2013 Wind Technologies Market Report* (Wiser and Bolinger 2014). This report shows that capacity-weighted installed capital costs for U.S. projects declined 13 percent from $2,262/kW (in 2013$) in 2009 to $1,960/kW in 2012. While costs dropped again to $1,630/kW in 2013 and are expected to average $1,750/kW in 2014, these projects are heavily weighted toward lower cost projects in the interior region of the U.S. Thus, we conservatively assume that average U.S. installed costs will stay fixed at 2012 levels over time based on a larger sample of projects, and assuming the wind industry invests in technology improvements that result in increases in capacity factors. Current capacity factors are based on data from recent projects and studies that reflect recent technology advances (Wiser 2014). We assume capacity factors will increase over time to achieve a reduction in the overall cost of electricity based on mid-range projections from 13 independent studies and 18 scenarios (Lantz 2013). We also assume higher fixed O&M costs than EIA based on mid-range estimates (EIA 2014, Wiser 2012, Black & Veatch 2012, NREL 2012).

- **Offshore wind**. Initial capital costs are based on data from recent and proposed projects located in shallow water in Europe and the U.S. from NREL's offshore wind database (Schwartz 2010). We assume capital costs decline and capacity factors increase over time based on mid-range projections from several studies (Lantz 2013, EIA 2014, NREL 2012, Black & Veatch 2012, BVG 2012, Prognos 2013). We also assume higher fixed O&M costs than EIA based on mid-range estimates (EIA 2014, Wiser 2012, Black & Veatch 2012, NREL 2012).

- **Solar photovoltaics (PV)**. We assume lower initial capital costs than EIA based on data from a large sample of recent utility scale and rooftop PV projects installed in the U.S. through the second quarter of 2014 (SEIA 2014). We assume future solar PV costs for utility scale, residential, and commercial systems will decline over time based on mid-range projections from the DOE Sunshot Vision Study's 62.5 percent by 2020 and 75 percent by 2040 price scenarios. In addition, we use slightly lower capacity factors for solar PV than EIA based on NREL data (NREL 2012).

- **Solar CSP**. We assume concentrating solar plants will include six hours of storage and used the price projection and O&M costs from the DOE Sunshot Vision Study's 62.5 percent by 2020 and 75 percent by 2040 price scenarios.
- **Biomass**. We use EIA's initial capital costs for new fluidized bed combustion plants, but do not include EIA's projected cost reductions due to learning because we assume it's a mature technology. However, we assume that biopower technology transitions to more efficient integrated gasification combined cycle plants over time, resulting in a gradual decline in the heat rate from 13,500 Btu/kWh to 9,500 Btu/kWh by 2035. For biomass co-firing in coal plants, we reduce EIA's co-firing limit from 15 percent to 10 percent to reflect potential resource supply constraints near clusters of coal plants, and assume higher capital costs based on data from Black & Veatch (2012). We also use a slightly different biomass supply curve than EIA based on a UCS analysis of data from DOE's Updated Billion Ton study that includes additional sustainability criteria, resulting in a potential biomass supply of 680 million tons per year by 2030 (UCS 2012, ORNL 2011).
- **Geothermal and hydro**. We didn't make any changes to NREL's assumptions for geothermal and hydro, which are site specific.
- **Energy efficiency**. We estimated future electricity savings from existing state energy efficiency resource standards (EERS) and implemented this savings as a demand reduction in ReEDS.

Table A1.1. Comparison of Overnight Capital Costs for Electric Generation Technologies (2013$/kW). Abbreviations are as follows: combined-cycle (CC), combustion turbine (CT), carbon capture and storage (CCS), pulverized coal (PC), integrated gasification and combined-cycle (IGCC) and photovoltaic (PV).

	UCS 2014					EIA AEO 2014			
Technology	2010	2020	2030	2040	2050	2010	2020	2030	2040
Natural Gas CC	1,036	1,036	1,036	1,036	1,036	1,043	1,036	914	826
Natural Gas-CC-CCS	n/a	3,005	2,723	2,513	2,407	n/a	2,052	1,777	1,559
Natural Gas CT	689	689	689	689	689	688	670	575	515
Coal-Supercritical PC	3,306	3,306	3,306	3,306	3,306	2,988	3,051	2,802	2,562
Coal-IGCC	n/a	4,482	4,482	4,482	4,482	n/a	3,828	3,412	3,067
Coal-PC-CCS	n/a	6,166	5,808	5,548	5,372	n/a	5,272	4,736	4,231
Nuclear	n/a	6,529	6,529	6,529	6,529	n/a	4,905	4,376	3,831
Biomass	4,187	4,187	4,187	4,187	4,187	4,188	3,862	3,492	3,112
Solar PV-Utility		1,925	1,604			3,943	3,334	2,963	2,625
Solar PV-Residential	Used NREL's Sunshot scenarios,					7,636	3,850	2,823	2,823
Solar PV-Commercial	Used NREL's Sunshot scenarios,					6,545	2,951	2,567	2,567
Solar CSP-With Storage		3,299			2,496	n/a	n/a	n/a	n/a
Wind-Onshore	2,280	1,969	1,969	1,969	1,969	2,254	2,301	2,113	1,932
Wind-Offshore	n/a	5,329	4,620	4,249	3,557	6,343	6,330	5,608	4,932

Table A1.2. Operation and Maintenance (O&M) and Heat Rate Assumptions. Abbreviations are as follows: Combined-cycle (CC), combustion turbine (CT), carbon capture and storage (CCS), pulverized coal (PC), photovoltaic (PV), integrated gasification and combined-cycle (IGCC).

Technology	Fixed O&M ($/kW-yr)	Variable O&M ($/MWh)	Heat Rate (Btu/kWh)	
			2010	2050
Natural Gas-CC	15.65	3.33	6430	6333
Natural Gas-CC-CCS	32.36	6.90	7525	7493
Natural Gas CT	7.17	10.56	9750	8550
Coal-Supercritical PC	31.75	4.55	8800	8740
Coal-IGCC	52.32	7.35	8700	7450
Coal-IGCC-CCS	67.68	4.53	10700	8307
Nuclear	94.98	2.18	10452	10452
Biomass	107.56	5.36	13500	9500
Solar PV-utility	16.30	0.00	n/a	n/a
Solar PV-Residential	NREL	0.00	n/a	n/a
Solar PV-Commercial	NREL	0.00	n/a	n/a
Solar CSP-With Storage	68.49	0.00	n/a	n/a
Wind-Onshore	51.82	0.00	n/a	n/a
Wind-Offshore	103.63	0.00	n/a	n/a

Table A1.3. Comparison of Solar Capacity Factors.

Technology	UCS 2014	EIA AEO 2014
Solar PV-utility	16-28%	21-32%
Solar CSP-With Storage	27-54%	n/a

Table A1.4. Comparison of Wind Capacity Factors.

	UCS 2014					EIA AEO 2014			
Technology	2012	2020	2030	2040	2050	2010	2020	2030	2040
Wind-Onshore Class 3	31%	35%	37%	39%	40%	28%	29%	29%	29%
Wind-Onshore Class 4	35%	39%	41%	43%	45%	32%	33%	33%	33%
Wind-Onshore Class 5	40%	45%	48%	50%	51%	39%	39%	39%	39%
Wind-Onshore Class 6	44%	50%	53%	53%	53%	45%	46%	46%	46%
Wind-Offshore Class 5	36%	38%	40%	42%	44%	27%	27%	27%	27%
Wind-Offshore Class 6	45%	47%	49%	51%	53%	34%	34%	34%	34%
Wind-Offshore Class 7	52%	52%	53%	53%	53%	40%	40%	40%	40%

References

Black and Veatch. 2012. *Cost and Performance Data for Power Generation Technologies.* Golden, CO: National Renewable Energy Laboratory. Online at *http://bv.com/docs/reports-studies/nrel-cost-report.pdf*.

BVG Associates. 2012. *Offshore wind cost reduction pathways*. Online at *http://www.thecrownestate.co.uk/media/305086/BVG%20OWCRP%20technology%20work%20stream.pdf*.

Energy Information Administration (EIAa). 2014. *Assumptions to the annual energy outlook 2014*. Online at *http://www.eia.gov/forecasts/aeo/assumptions/pdf/0554(2014).pdf*.

Energy Information Administration (EIAb). 2014. *Updated capital cost estimates for utility scale electricity generating plants*. Washington, DC: U.S. Department of Energy. Online at *http://www.eia.gov/forecasts/capitalcost/pdf/updated_capcost.pdf*.

Henry, R. 2013. Deal reached on Vogtle cost overruns. *The Augusta Chronicle*. Online at *http://chronicle.augusta.com/news/metro/2013-07-31/deal-reached-vogtle-cost-overruns*.

Lantz, E., R. Wiser and M. Hand. 2012. *IEA Wind Task 26: The Past and Future Cost of Wind Energy*. National Renewable Energy Laboratory. NREL/TP-6A20-53510. Online at *http://www.nrel.gov/docs/fy12osti/53510.pdf*.

Lazard, 2013. *Levelized cost of electricity analysis – version 7.0*. Online at *http://gallery.mailchimp.com/ce17780900c3d223633ecfa59/files/Lazard_Levelized_Cost_of_Energy_v7.0.1.pdf*.

National Renewable Energy Laboratory (NREL). 2012. Renewable electricity futures study. NREL/TP-6A20-52409. Golden, CO. Online at *http://www.nrel.gov/analysis/re_futures/*.

Oak Ridge National Laboratory—U.S.Department of Energy (ORNL). 2011.*U.S. billion-ton update: Biomass supply for a bioenergy and bioproducts industry.* ORNL/TM-2011/224. Oak Ridge, TN. Online at *http://www1.eere.energy.gov/bioenergy/pdfs/billion_ton_update.pdf*.

Penn, I. 2012. Progress energy raises price tag, delays start date of Levy nuclear plant. *Tampa Bay Times*. Online at *http://www.tampabay.com/news/business/energy/progress-energy-raises-price-tag-delaysstart-date-of-levy-nuclear-plant/1227830*.

Prognos AG and The Fitchner Group. 2013. *Cost Reduction Potentials of Offshore Wind Power in Germany*. Online at *http://www.offshore-stiftung.com/60005/Uploaded/SOW_Download%7CEN_ShortVersion_CostReductionPotentialsofOffshoreWindPower.pdf*.

SNL Energy. 2013. Project specific data on different renewable and conventional electricity generation technologies accessed by UCS.

Solar Energy Industries Association (SEIA). 2014. *U.S. Solar Market Insight Q2 2014 Report*. Online at www.seia.org/smi.

Schwartz, M., D. Heimiller, S. Haymes, and W. Musial. 2010. *Assessment of offshore wind energy resources for the United States.* Golden, CO: National Renewable Energy Laboratory.

NREL/TP-500-45889.

U.S. Department of Energy (DOE). 2014. *Wind Vision: A New Era for Wind Power in the United States (Industry Preview).* DOE/GO-102014-4557. Online at http://energy.gov/eere/wind/downloads/draft-industry-preview-wind-vision-brochure.

U.S. Department of Energy (DOE). 2012. S*unshot vision study.* Online at *http://www1.eere.energy.gov/solar/pdfs/47927.pdf.*

Union of Concerned Scientists (UCS). 2014. *Strengthening the EPA's Clean Power Plan: Increasing renewable energy use will achieve greater emission reductions.* Online at http://www.ucsusa.org/sites/default/files/attach/2014/10/Strengthening-the-EPA-Clean-Power-Plan.pdf.

Union of Concerned Scientists (UCS). 2012. *The promise of biomass: clean power and fuel—if handled right.* Online at *http://www.ucsusa.org/assets/documents/clean_vehicles/Biomass-Resource-Assessment.pdf.*

Vukmanovic, O. 2012. UK nuclear build requires taxpayer rescue. Citi Reuters. Online at http://uk.reuters.com/article/2012/05/08/uk-nuclear-britain-edf-idUKBRE8470XC20120508.

Wald, M. 2012. A higher price tag for a nuclear project The New York Times. Online at http://green.blogs.nytimes.com/2012/05/11/a-higherprice-tag-for-a-nuclear-project/.

Wiser, R., and M. Bolinger. 2014. *2013 wind technologies market report.* Washington, DC: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Online at *http://eetd.lbl.gov/sites/all/files/2013_wind_technologies_market_report_final3.pdf,* accessed on September 22, 2014.

Wiser, R., E. Lantz, M. Bolinger, and M. Hand. 2012. *Recent developments in the levelized cost of energy from U.S. wind power projects.* Online at *http://emp.lbl.gov/sites/all/files/wind-energy-costs-2-2012_0.pdf*.

Appendix 2. State and Regional Renewable Energy Generation under the UCS Demonstrated Growth Approach, 2017 to 2030

	EPA Proposed Renewables Approach (GWh)		UCS Demonstrated Renewables Growth Approach (GWh)	
State	2020	2030	2020	2030
Alabama	4,597	14,293	5,711	16,246
Alaska	62	163	322	1,036
Arizona	2,151	3,663	6,762	16,120
Arkansas	2,288	4,709	2,927	8,403
California	37,968	41,151	92,177	121,294
Colorado	7,845	10,840	12,371	22,360
Connecticut	1,071	3,114	7,329	10,473
Delaware	248	1,038	1,741	3,046
Florida	7,490	22,110	10,688	36,391
Georgia	5,428	12,231	7,252	22,538
Hawaii	1,047	1,047	2,619	4,485
Idaho	3,186	3,197	4,774	9,224
Illinois	10,563	17,818	20,146	37,889
Indiana	4,474	7,547	8,129	19,643
Iowa	8,566	8,566	20,313	21,558
Kansas	7,239	8,885	14,893	18,405
Kentucky	551	1,714	3,403	16,553
Louisiana	3,349	6,892	4,950	14,993
Maine	3,612	3,612	4,950	5,033
Maryland	1,698	5,982	12,758	19,946
Massachusetts	2,962	8,613	10,618	16,387

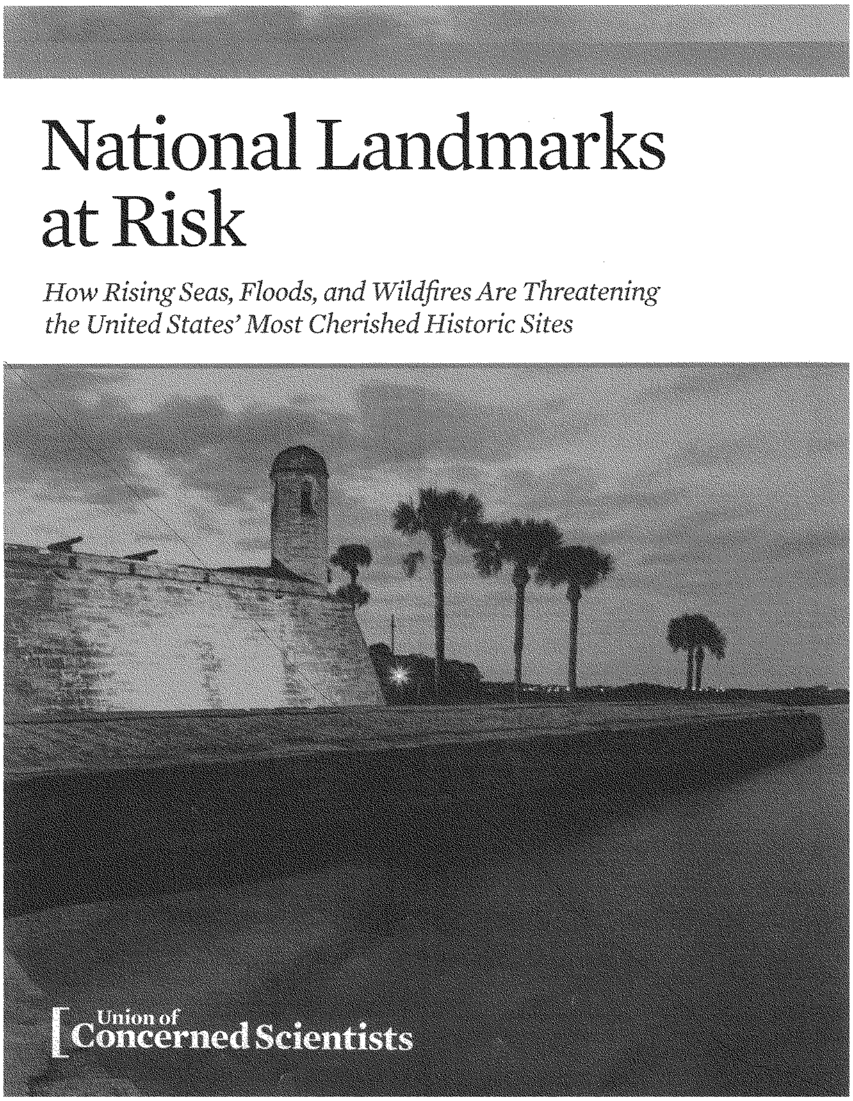
2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
3,484	3,970	4,712	5,711	6,722	7,744	8,777	9,820	10,872	11,933	13,002	14,078	15,159	16,246
171	204	254	322	390	459	529	600	671	743	816	889	962	1,036
4,414	5,039	5,894	6,762	7,644	8,539	9,446	10,366	11,297	12,240	13,195	14,160	15,136	16,120
1,778	2,029	2,411	2,927	3,450	3,980	4,516	5,057	5,604	6,155	6,711	7,272	7,836	8,403
73,005	79,337	86,055	92,177	94,981	97,818	100,686	103,582	106,506	109,456	112,431	115,431	118,451	121,294
9,641	10,531	11,444	12,371	13,312	14,267	15,236	16,218	17,213	18,219	19,238	20,269	21,310	22,360
5,674	6,186	7,019	7,329	7,640	7,953	8,267	8,581	8,896	9,211	9,527	9,842	10,158	10,473
1,363	1,503	1,619	1,741	1,866	1,991	2,119	2,247	2,377	2,508	2,641	2,775	2,910	3,046
5,295	6,473	8,268	10,688	13,138	15,616	18,123	20,657	23,218	25,805	28,419	31,056	33,713	36,391
4,045	4,745	5,813	7,252	8,709	10,183	11,674	13,181	14,703	16,242	17,797	19,365	20,945	22,538
1,643	1,718	1,819	2,619	2,723	2,828	2,934	3,041	3,149	3,258	3,368	3,479	3,591	4,485
3,559	3,955	4,362	4,774	5,194	5,619	6,051	6,488	6,931	7,379	7,833	8,292	8,756	9,224
14,589	16,408	18,285	20,146	22,067	23,983	25,896	27,840	29,773	31,385	33,004	34,630	36,258	37,889
5,074	5,902	7,013	8,129	9,253	10,385	11,523	12,669	13,821	14,977	16,139	17,305	18,473	19,643
19,522	19,977	20,180	20,313	20,468	20,622	20,758	20,921	21,063	21,181	21,303	21,406	21,478	21,558
12,957	13,597	14,243	14,893	15,549	16,209	16,873	17,543	17,982	18,083	18,187	18,276	18,337	18,405
623	1,229	2,155	3,403	4,665	5,941	7,230	8,532	9,845	11,169	12,504	13,846	15,196	16,553
2,844	3,303	4,004	4,950	5,910	6,882	7,865	8,858	9,860	10,871	11,891	12,919	13,953	14,993
4,834	4,931	4,937	4,950	4,967	4,987	4,998	5,010	5,023	5,029	5,031	5,033	5,031	5,033
9,790	11,579	12,081	12,758	13,443	14,136	14,838	15,546	16,262	16,986	17,717	18,454	19,198	19,946
8,894	9,466	10,049	10,618	11,190	11,763	12,338	12,915	13,493	14,071	14,650	15,229	15,808	16,387

Michigan	4,776	8,056	11,573	22,979
Minnesota	7,889	7,889	19,041	28,341
Mississippi	2,499	5,458	2,871	8,701
Missouri	1,638	2,764	6,922	16,580
Montana	1,599	2,723	2,577	4,951
Nebraska	1,856	3,819	4,138	7,756
Nevada	3,761	6,406	7,471	13,166
New Hampshire	2,220	4,822	2,161	3,325
New Jersey	2,421	10,147	18,562	26,328
New Mexico	3,261	4,722	5,564	8,430
New York	8,344	24,262	13,860	28,828
North Carolina	4,477	11,668	11,621	26,674
North Dakota	5,460	5,460	6,870	7,290
Ohio	3,287	13,776	12,141	28,703
Oklahoma	11,743	15,579	17,906	28,304
Oregon	9,132	12,567	11,616	19,711
Pennsylvania	8,430	35,331	12,882	27,825
Rhode Island	164	476	1,367	2,191
South Carolina	3,549	9,676	4,091	13,252
South Dakota	1,819	1,819	3,727	5,584
Tennessee	1,385	4,306	3,821	15,299
Texas	46,880	85,963	81,548	129,521
Utah	1,393	2,373	2,092	5,842
Virginia	4,459	11,192	5,932	18,707
Washington	10,408	17,726	13,212	23,818
West Virginia	2,451	11,704	2,581	6,226
Wisconsin	4,066	6,859	8,605	16,259
Wyoming	5,536	9,428	5,567	8,731
National	**281,295**	**524,154**	**555,154**	**995,343**

9,095	9,642	10,467	11,573	12,686	13,808	14,935	16,070	17,211	18,357	19,508	20,663	21,820	22,979
15,153	16,034	16,925	19,041	19,944	20,854	21,770	22,693	23,623	24,557	25,497	26,442	27,390	28,341
1,639	1,908	2,318	2,871	3,431	3,997	4,568	5,145	5,728	6,315	6,906	7,501	8,100	8,701
2,698	5,352	6,022	6,922	8,149	9,062	9,982	10,909	11,842	12,781	13,725	14,673	15,625	16,580
1,928	2,139	2,356	2,577	2,800	3,027	3,258	3,491	3,727	3,967	4,209	4,454	4,701	4,951
3,100	3,443	3,790	4,138	4,490	4,844	5,200	5,559	5,921	6,284	6,650	7,017	7,386	7,756
5,915	6,422	6,943	7,471	8,008	8,552	9,105	9,665	10,232	10,805	11,386	11,974	12,568	13,166
1,812	1,928	2,046	2,161	2,277	2,392	2,508	2,625	2,741	2,858	2,975	3,091	3,208	3,325
13,729	15,333	16,985	18,562	19,331	20,104	20,879	21,655	22,432	23,210	23,989	24,769	25,548	26,328
4,781	5,036	5,298	5,564	5,834	6,108	6,386	6,668	6,953	7,242	7,534	7,830	8,129	8,430
10,546	11,283	12,386	13,860	15,342	16,833	18,327	19,822	21,320	22,819	24,321	25,824	27,326	28,828
5,489	9,152	10,203	11,621	13,055	14,507	15,975	17,459	18,959	20,474	22,005	23,550	25,106	26,674
6,602	6,756	6,825	6,870	6,922	6,974	7,020	7,075	7,123	7,163	7,204	7,239	7,263	7,290
7,571	9,050	10,535	12,141	13,758	15,386	17,023	18,671	20,328	21,992	23,663	25,340	27,020	28,703
15,008	15,959	16,926	17,906	18,899	19,906	20,924	21,951	22,989	24,036	25,092	26,156	27,226	28,304
9,345	10,091	10,849	11,616	12,390	13,174	13,966	14,766	15,574	16,389	17,211	18,039	18,874	19,711
9,494	10,309	11,410	12,882	14,361	15,849	17,341	18,834	20,329	21,826	23,325	24,826	26,325	27,825
1,027	1,155	1,285	1,367	1,448	1,530	1,612	1,695	1,777	1,860	1,943	2,025	2,108	2,191
2,169	2,589	3,229	4,091	4,964	5,847	6,741	7,644	8,557	9,479	10,410	11,350	12,297	13,252
3,139	3,333	3,529	3,727	3,926	4,126	4,327	4,531	4,735	4,941	5,148	5,356	5,563	5,584
1,395	1,924	2,732	3,821	4,923	6,036	7,162	8,298	9,444	10,600	11,765	12,937	14,115	15,299
68,178	72,562	77,028	81,548	86,131	90,777	95,471	100,212	105,000	109,831	114,703	119,611	124,551	129,521
1,320	1,487	1,744	2,092	2,445	2,804	3,168	3,536	3,910	4,287	4,670	5,057	5,448	5,842
3,252	3,837	4,729	5,932	7,149	8,381	9,627	10,887	12,159	13,445	14,744	16,055	17,376	18,707
10,238	11,215	12,209	13,212	14,227	15,254	16,292	17,340	18,398	19,465	20,542	21,628	22,720	23,818
1,648	1,899	2,238	2,581	2,928	3,280	3,635	3,995	4,358	4,725	5,095	5,469	5,846	6,226
6,942	7,310	7,863	8,605	9,352	10,105	10,861	11,623	12,389	13,158	13,930	14,705	15,482	16,259
4,702	4,984	5,273	5,567	5,865	6,168	6,475	6,786	7,101	7,419	7,742	8,069	8,399	8,731

	EPA Proposed Renewables Approach (GWh)		UCS Demonstrated Renewables Growth Approach (GWh)	
Clean Power Plan Region	2020	2030	2020	2030
Alaska	62	163	322	1,036
East Central	22,994	89,170	66,597	130,780
Hawaii	1,047	1,047	2,619	4,485
North Central	49,251	66,777	105,325	176,122
Northeast	18,373	44,900	40,285	66,237
South Central	73,355	125,847	126,364	207,382
Southeast	29,974	81,455	49,459	155,654
West	86,239	114,795	164,183	253,647

2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
171	204	254	322	390	459	529	600	671	743	816	889	962	1,036
46,847	53,509	59,598	66,597	72,837	79,129	85,462	91,835	98,246	104,693	111,175	117,689	124,223	130,780
1,643	1,718	1,819	2,619	2,723	2,828	2,934	3,041	3,149	3,258	3,368	3,479	3,591	4,485
82,813	90,715	97,109	105,325	112,768	119,919	127,073	134,330	141,578	148,500	155,458	162,419	169,351	176,122
32,788	34,949	37,723	40,285	42,864	45,459	48,050	50,648	53,250	55,848	58,446	61,045	63,638	66,237
103,867	110,892	118,401	126,364	134,429	142,598	150,849	159,181	167,355	175,261	183,235	191,251	199,288	207,382
24,139	31,987	39,430	49,459	59,605	69,871	80,250	90,736	101,326	112,018	122,808	133,684	144,632	155,654
128,847	140,236	152,428	164,183	172,700	181,330	190,067	198,905	207,841	216,869	225,989	235,203	244,492	253,647



National Landmarks at Risk

How Rising Seas, Floods, and Wildfires Are Threatening the United States' Most Cherished Historic Sites

Union of Concerned Scientists

National Landmarks at Risk

How Rising Seas, Floods, and Wildfires Are Threatening the United States' Most Cherished Historic Sites

Debra Holtz
Adam Markham
Kate Cell
Brenda Ekwurzel

May 2014

Union of Concerned Scientists

© 2014 Union of Concerned Scientists
All rights reserved

Debra Holtz is a communications consultant for the Union of Concerned Scientists (UCS). She is also a professional journalist whose work includes the book *Of Unknown Origin* and many articles for publications including the *San Francisco Chronicle*.

Adam Markham is director of the Climate Impacts Initiative at UCS. He has more than 20 years of experience working on conservation and climate change issues in the United States and Europe.

Kate Cell is a senior campaign organizer at UCS. She specializes in involving new expert constituencies such as economists, social scientists, and health professionals in the work of the UCS Climate & Energy Program.

Brenda Ekwurzel is a senior climate scientist with the UCS Climate & Energy Program. She is leading the organization's climate science education work aimed at strengthening support for sound U.S. climate policies.

The Union of Concerned Scientists puts rigorous, independent science to work to solve our planet's most pressing problems. Joining with citizens across the country, we combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe, and sustainable future.

More information about UCS is available on the UCS website (*www.ucsusa.org*).

Designed by:
Tyler Kemp-Benedict, Bangkok, Thailand
www.hardworkingtype.com

Cover photo: © William Trinkle Photography

North America's oldest masonry fort, the Castillo de San Marcos in St. Augustine, FL, is threatened by rising seas and storms.

[CONTENTS]

iv Figures
v About the Project Team
vii Acknowledgments
1 **Introduction**

[SITES]

4 BOSTON HISTORIC DISTRICTS Boston's Historic Districts and Faneuil Hall Are Increasingly Vulnerable to Floods
7 STATUE OF LIBERTY & ELLIS ISLAND Protecting the Statue of Liberty and Ellis Island from Rising Tides
10 HARRIET TUBMAN NATIONAL MONUMENT Monument to Harriet Tubman's Legacy Is Vulnerable to Rising Sea Levels
13 HISTORIC ANNAPOLIS, MD Planning to Prevent Storm Damage in a Historic Colonial Town
16 HISTORIC JAMESTOWN, VA Rising Seas Threaten to Inundate Jamestown Island
18 FORT MONROE NATIONAL MONUMENT Freedom's Fortress Is at Risk from Higher Seas and Heavier Rains
21 NASA'S COASTAL FACILITIES Multiple NASA Sites Face Challenges from Rising Seas
26 CAPE HATTERAS LIGHTHOUSE Saving an Icon: Moving the Cape Hatteras Lighthouse Away from the Shifting Shoreline
28 HISTORIC CHARLESTON, SC Preserving the Past by Planning for Future Floods
30 HISTORIC ST. AUGUSTINE, FL & CASTILLO DE SAN MARCOS Adapting to Climate Change Is Vital to Protecting St. Augustine's Distinctive Heritage
33 PREHISTORIC FLORIDA SHELL STRUCTURES A Race against Time for Florida's Prehistoric Shell Structures
36 MESA VERDE NATIONAL PARK Mesa Verde's Ancient Artifacts and Dwellings Are Increasingly Exposed to Wildfires and Flooding
39 BANDELIER NATIONAL MONUMENT & SANTA CLARA PUEBLO Pueblos Ancient and Modern Face Increased Risks from Fires and Floods
41 GROVELAND, CA Groveland and Other California Gold Rush–Era Towns Are Imperiled by Wildfires
44 CÉSAR CHÁVEZ NATIONAL MONUMENT California Farmworkers Championed by César Chávez Are Now Threatened by Extreme Heat and Drought
47 BERING LAND BRIDGE NATIONAL MONUMENT & SHISHMAREF, CAPE KRUSENSTERN NATIONAL MONUMENT & KIVALINA Native Villages and Ancestral Lands in Alaska Face Rapid Coastal Erosion
50 PU'UHONUA O HŌNAUNAU & KALOKO-HONOKŌHAU NATIONAL HISTORICAL PARKS Sea Level Rise Threatens Hawaiian Cultural Heritage Sites

52 **The Science behind the Changing Risks to Our National Treasures**
57 Endnotes
59 References

[FIGURES]

1 Figure 1. Map of Case Study Sites
21 Figure 2. NASA Coastal Facilities
52 Figure 3. Shift in Extreme Events
53 Figure 4. Factors That Influence Risk Include Exposure, Vulnerability, and Hazards
54 Figure 5. Storm Surge on a Higher Sea
54 Figure 6. Changes in Wildfire Size and Season
55 Figure 7. Percentage Change in Very Heavy Precipitation

[ABOUT THE PROJECT TEAM]

AUTHORS

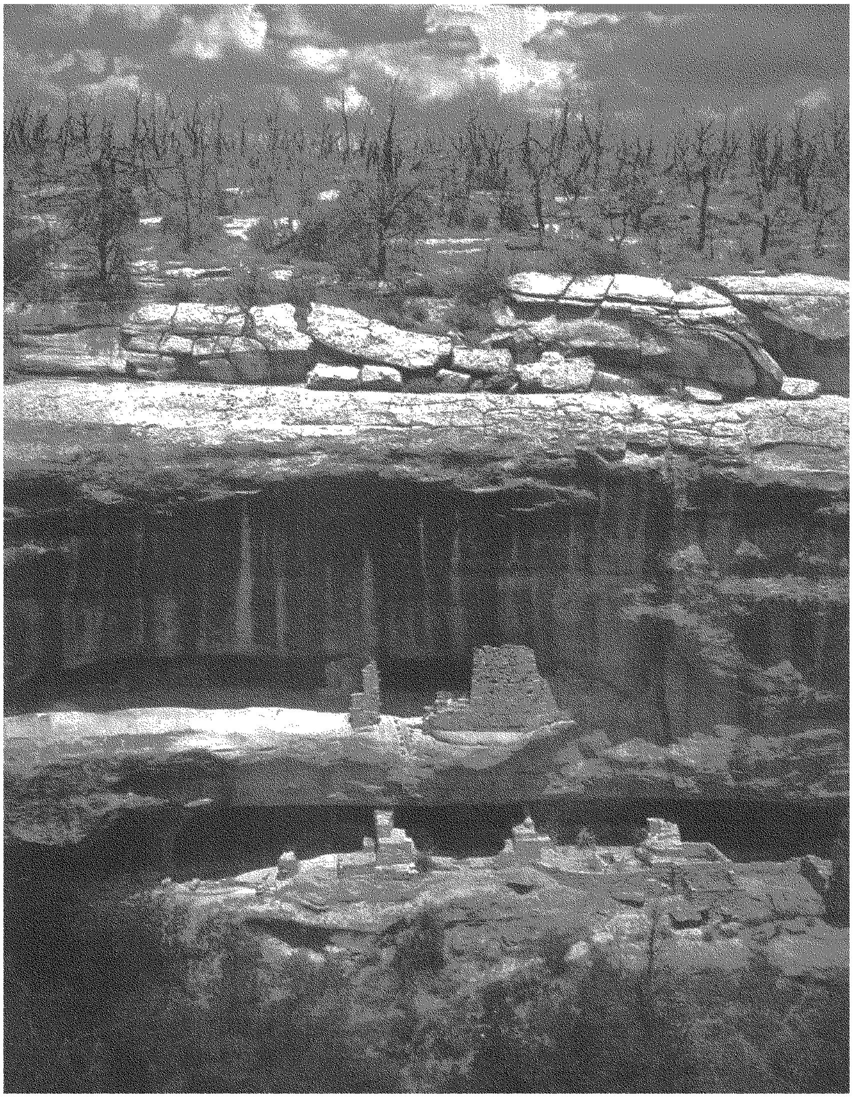
Debra Holtz
Adam Markham
Kate Cell
Brenda Ekwurzel

UCS TEAM

Project Manager: Kate Cell
Leadership: Angela Anderson, Nancy Cole, Adam Markham, Suzanne Shaw
Climate Science: Kristina Dahl, Brenda Ekwurzel, Melanie Fitzpatrick
Research: Kathy Pillsbury
Review: Carina Barnett-Loro, Rob Cowin, Lisa Nurnberger, Seth Shulman
Editing: Steven Marcus
Production: Heather Tuttle, Bryan Wadsworth
Design: Tyler Kemp-Benedict
Administrative Support: Andrew Klein

EXTERNAL REVIEWERS

Boston Historic Districts: Benjamin Carp (Tufts University), Nancy Girard (City of Boston), Anthony Janetos (Boston University)
Statue of Liberty & Ellis Island: Bob Kopp (Rutgers University), Jim Miller (Rutgers University)
Harriet Tubman National Monument: Audrey Peterman (Earthwise Productions Inc.), Alan Spears (National Parks Conservation Association)
Historic Annapolis: Jane McWilliams, Sara Phillips (U.S. Naval Academy), Jean Russo (Archives of Maryland Online)
Historic Jamestown: Dorothy Geyer (National Park Service), Molly Mitchell (Virginia Institute of Marine Science)
Fort Monroe National Monument: Ray Gavins (Duke University), Pamela Goddard (National Parks Conservation Association), Adam Goodheart (Washington College), Molly Mitchell (Virginia Institute of Marine Science), Audrey Peterman (Earthwise Productions Inc.), Alan Spears (National Parks Conservation Association)
NASA's Coastal Facilities: Russell DeYoung (NASA), Jonathan McDowell (Harvard University)
Cape Hatteras Lighthouse: Thayer Broili (National Park Service), Orrin Pilkey (Duke University)
Historic Charleston: Rebecca Beavers (National Park Service)
Historic St. Augustine & Castillo de San Marcos: Rebecca Beavers (National Park Service), Len Berry (Florida Atlantic University)
Prehistoric Florida Shell Structures: Len Berry (Florida Atlantic University), Margo Schwadron (National Park Service)
Mesa Verde National Park: Todd Sanford
Bandelier National Monument & Santa Clara Pueblo: Rory Gauthier (National Park Service), Barbara Judy (National Park Service), Lauren Meyer (National Park Service)
Groveland, CA: Todd Sanford
César Chavez National Monument: Erik Loomis (University of Rhode Island), Todd Sanford
Bering Land Bridge: Shelby Anderson (Portland State University), Jeremy Karchut (National Park Service), Tony Weyiouanna (Shishmaref Native Corporation)
Pu'uhonua o Hōnaunau and Kaloko-Honokōhau National Historical Parks: Stanton Enomoto (National Park Service), Adam Johnson (National Park Service)



[ACKNOWLEDGMENTS]

This report was made possible by support from The Barr Foundation, The Energy Foundation, The Grantham Foundation for the Protection of the Environment, the Mertz Gilmore Foundation, and UCS members.

The UCS project team would like to acknowledge the assistance of numerous people in the preparation of this report. We would especially like to thank Marcy Rockman, Climate Change Adaptation Coordinator for Cultural Resources at the National Park Service, who provided invaluable advice, contacts, and guidance throughout. Particular thanks are also due to Shelby Anderson, Amanda Babson, Deborah Bailin, Rebecca Beavers, Karen Brown, Janet Cakir, Lizzy Carlyle, Lisa Craig, Peter DeBrine, Stanton Enomoto, Rory Gauthier, Ray Gavins, Dorothy Geyer, Patrick Gonzalez, Adam Goodheart, Andy Hansen, Cat Hoffman, Adam Johnson, Barbara Judy, Jeremy Karchut, Bob Krumenaker, Craig Lee, Steven Leibo, Ken Lustbader, Lisa Marrack, Lauren Meyer, Giselle Mora-Bourgeios, Shawn Norton, Diane Paviek, Audrey Peterman, Virginia Salazar-Halfmoon, Stephen Saunders, Margo Schwadron, Rhonda Sincavage, Leigh Welling, Jenna Wiser, Peter Wood, and Tony Wood.

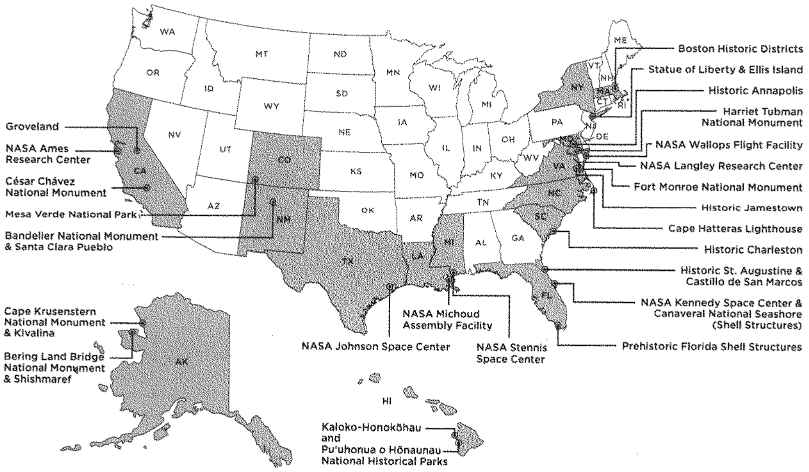
The opinions expressed herein do not necessarily reflect those of the organizations that funded the work or the individuals who reviewed it. The Union of Concerned Scientists bears sole responsibility for the report's content.

(Left:) At Mesa Verde National Park in Colorado, the top of the cliff shows the destruction of a forest fire.

© Kojihirano/Dreamstime.com

Many of the United States' iconic landmarks and heritage sites are at risk as never before. Sea level rise, coastal erosion, increased flooding, heavy rains, and more frequent large wildfires are damaging archaeological resources, historic buildings, and cultural landscapes across the nation.

FIGURE 1. Map of Case Study Sites


WA
OR
ID
MT
ND
SD
WY
NV
UT
CO
AZ
NM
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
MI
IL
IN
OH
KY
TN
MI
AL
GA
FL
SC
NC
VA
WV
PA
NY
ME
VT
NH
MA
CT
RI
NJ
DE
CA
AK
HI
Groveland
NASA Ames Research Center
César Chávez National Monument
Mesa Verde National Park
Bandelier National Monument & Santa Clara Pueblo
Cape Krusenstern National Monument & Kivalina
Bering Land Bridge National Monument & Shishmaref
Boston Historic Districts
Statue of Liberty & Ellis Island
Historic Annapolis
Harriet Tubman National Monument
NASA Wallops Flight Facility
NASA Langley Research Center
Fort Monroe National Monument
Historic Jamestown
Cape Hatteras Lighthouse
Historic Charleston
Historic St. Augustine & Castillo de San Marcos
NASA Kennedy Space Center & Canaveral National Seashore (Shell Structures)
Prehistoric Florida Shell Structures
NASA Michoud Assembly Facility
NASA Johnson Space Center
NASA Stennis Space Center
Kaloko-Honokōhau and Pu'uhonua o Hōnaunau National Historical Parks

(Left:) While NASA undertakes research on other planets (as with the Mars-bound spacecraft being launched in this photograph) and the natural and man-made changes that affect the habitability of our own planet, the agency faces challenges from rising seas and other impacts of climate change.[1]

© NASA/Bill Ingalls

From sea to rising sea, a remarkable number of the places where American history was made are already under threat. The geographic and cultural quilt that tells the American story is fraying at the edges—and even beginning to be pulled apart—by the impacts of climate change.

This report is not a comprehensive analysis of climate change threats to all of the United States' historic places, monuments and memorials, but rather a selection of case studies that vividly illustrate an urgent problem. These examples represent just a few of the many that could have been included, but the places they examine symbolize many of the rich and diverse elements of the American experience. The stories were chosen because the science behind the risks they face is robust, and because together they shine a spotlight on the different kinds of climate impacts already affecting the United States' cultural heritage.

The Range and Scale of Impacts Are Alarming

The range and scale of impacts are alarming. Coastal erosion in Alaska is washing away irreplaceable archaeological sites that chronicle some of the earliest people in the Americas, and also threatening the existence of native villages whose hunter-gatherer traditions originated thousands of years ago. Waves from rising seas batter the walls of ancient Hawaiian sacred sites and jeopardize future operations at Kennedy Space Center, where Apollo and many other pioneering missions were launched. Elsewhere along the Atlantic coast, historic districts, including those of Boston and Annapolis, are experiencing more frequent and severe coastal flooding and storm surges. Meanwhile, worsening wildfires are affecting nineteenth-century California Gold Rush towns and ancient pueblos in New Mexico and Colorado.

The landmarks discussed in this report include historic Jamestown, the U.S. Naval Academy, and Castillo de San Marcos. Ellis Island, where millions of Americans' ancestors entered the country for the first time, was closed to visitors for more than a year after Hurricane Sandy. Affected places include some of the oldest, as well as some of the most recently designated. Consider, for instance, that two of the nation's newest national monuments—sites commemorating Harriett Tubman in Maryland and Fort Monroe in Virginia—already face an imminent threat from sea level rise.

All of the case studies in this report draw on observations of impacts that are either consistent with, or attributable to, human-induced climate change based on multiple lines of scientific evidence. Some of the sites face the risk of severe damage or even eventual loss. Other case studies describe sites which are just now seeing the first signs of damage, or are experiencing disruptions to access and services that are likely to become worse, more frequent, or both. All provide a wake-up call: as the impacts of climate change continue, we must make hard choices now and take urgent steps to protect these sites and reduce the risks.

Just the Tip of the Iceberg

Many of the landmarks covered in this report are sites where innovative, enterprising, and visionary individuals made a difference. Many are places where our ancestors made their homes, and together represent the shared history that makes up the fabric of this nation's heritage. The stories these sites tell symbolize values—such as patriotism, freedom, democracy, respect for ancestors, and admiration for the pioneering and entrepreneurial spirit—that unite all Americans.

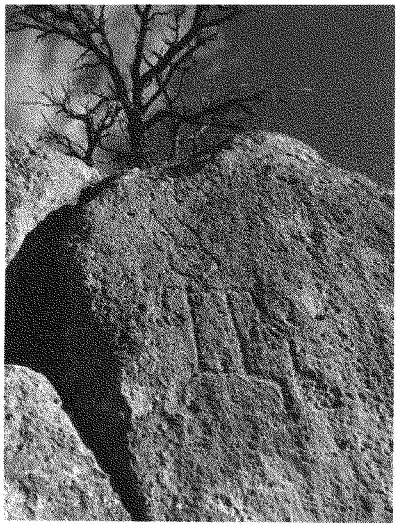
A significant number of the case studies in this report review climate change impacts now being observed in national parks, including Mesa Verde, Bandelier, Cape Hatteras, and the Everglades. The impacts are severe and numerous enough to have led Jon Jarvis, National Park Service (NPS) director, to state, "I believe climate change is fundamentally the greatest threat to the integrity of our national parks that we have ever experienced."[2]

Now, nearly 100 years since the founding of the NPS, the agency finds itself forced to develop new ways to protect the natural and cultural resources in its care from the impacts of a changing climate. A recent NPS analysis shows that 96 percent of its land is in areas of observed global warming over the past century and that at least 85 sites have already recorded changes attributable to climate change. Many more have seen consequences such as increases in winter temperature, decreased snowpack, and shifts in precipitation that are

> ***This report sounds a wake-up call: as the impacts of climate change continue, we must protect these sites and reduce the risks.***

consistent with climate change.[3] Another study by NPS scientists has determined that more than 100 national parks are vulnerable to the combined impacts of sea level rise and storm surges.[4]

As this report illustrates, climate change is no longer a distant threat for others to worry about. The consequences are already under way, forcing federal and state agencies, park managers, archaeologists, historic preservationists, engineers, architects, and others to spend time and resources to protect sites today and prepare for expected additional changes tomorrow. Although the report spotlights a sampling of such stories, it bears noting that the United States boasts more than 400 sites in its National Park System and that more than 80,000 sites are listed on the National Register of Historic Places, along with numerous state and local historic parks and buildings. Many of these are already affected too by flooding, coastal erosion, wildfires, and other impacts, and many more will see even greater risks in the coming decades.



© Adam Markham

An example of a petroglyph (or prehistoric rock carving) at Bandelier National Monument.

A Call to Action

Given the scale of the problem and the cultural value of the places at risk, it is not enough merely to plan for change and expect to adapt. We must begin now to prepare our threatened landmarks to face worsening climate impacts; climate resilience must become a national priority and we must allocate the necessary resources. We must also work to minimize the risks by reducing the carbon emissions that cause climate change. The science is clear that by abating our carbon pollution we can slow the pace of change and thereby lower the risks posed by extreme heat, flooding, and rising seas.

The case studies in this report also highlight some of the initiatives that the NPS, the National Aeronautics and Space Administration (NASA), the U.S. Navy, city leaders, and others are pursuing now to reduce the damage and bolster the resilience of these important places. From the installation of breakwaters to protect against coastal erosion on Jamestown Island to the flood-proofing of electrical utilities at the Statue of Liberty, major efforts are now being launched to lessen the impacts of climate change on the United States' national heritage.

More such efforts are needed. If future generations of Americans are to experience the joy and wonder that these extraordinary places engender, we must act now to protect them from the impacts of climate change.

> ***The United States boasts tens of thousands of national parks, landmarks, and historic places—many of them already affected by flooding, coastal erosion, wildfires, and other impacts.***

Boston's Historic Districts and Faneuil Hall Are Increasingly Vulnerable to Floods

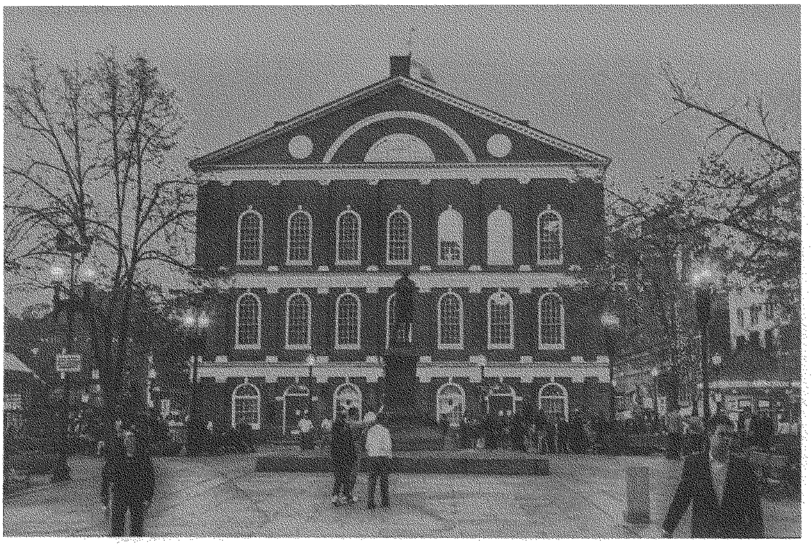
Founded in 1630 by English Puritans seeking religious freedom, Boston is one of the oldest cities in the United States and the birthplace of the American Revolution.[5] But in the city where the Sons of Liberty plotted independence from Great Britain, some cherished landmarks and historic districts are at risk from rising seas and worsening storm surges.[6]

Faneuil Hall, which is a stop on Boston's Freedom Trail and among the nation's best-preserved historic structures, is one such landmark. Ironically, merchant Peter Faneuil, who built this so-called "Cradle of Liberty" at his own expense, amassed much of his wealth through the slave trade.[7] While the current building dates from 1806, when Charles Bulfinch enlarged Faneuil Hall and moved the cupola,[8] it was first built as a commercial center in 1742 and located on the site of a small cove, which was filled in to accommodate the structure in an area called Dock Square. Over the years, Boston has grown in much this way—through a practice of "wharfing out," or constructing wharves and then filling them in. Consequently, Faneuil Hall is now a little more than a quarter-mile west of the present shoreline.[9]

Directly to the north of Faneuil Hall is the Blackstone Block, a compact district of narrow winding roads and alleys dating from the seventeenth century. The most intact network of early colonial streets in the United States, the district includes the Ebenezer Hancock House and the Union Oyster House, the oldest restaurant in Boston and a favorite of Daniel Webster and John F. Kennedy.[10] Even this far inland, Faneuil Hall and the Blackstone Block are vulnerable, lying within the city's 100-year tidal flood zone.[11] Since official tidal records began in Boston in 1921, extreme high tides—more than three and a half feet above the average high tide—have occurred 20 times, and half of those tides took place within the past 10 years.[12] As a result, several times a year exceptionally high tides already flood parts of the nineteenth-century warehouse neighborhoods around Fort Point Channel and the historic Long and Central wharves.[13]

The public meeting space on the original second floor is what gives Faneuil Hall its fame. Here, Samuel Adams and other Sons of Liberty held public meetings and planned protests against such British colonial policies as the Stamp Act. It is also the site of the initial meeting about the Tea Act, which prompted the Boston Tea Party. On December 16, 1773, members of the Sons of Liberty disguised themselves as Mohawk Indians, boarded three of the British East India Company's ships, and dumped an estimated 90,000 pounds of tea into Boston Harbor. In response, the British government

[***In the city where the Sons of Liberty plotted independence from Great Britain, some cherished landmarks and historic districts are at risk from rising seas and worsening storm surges.***]



© Carlos Alberto Ledesma Castaneda

Faneuil Hall continued to be vital to causes of liberty well into the nineteenth century, as William Lloyd Garrison and Frederick Douglass organized here for the abolition of slavery and Susan B. Anthony advocated women's rights.[14] *Now, however, this symbol of liberty and its surrounding neighborhoods are increasingly at risk from rising seas, storm surges, and coastal flooding.*[15]

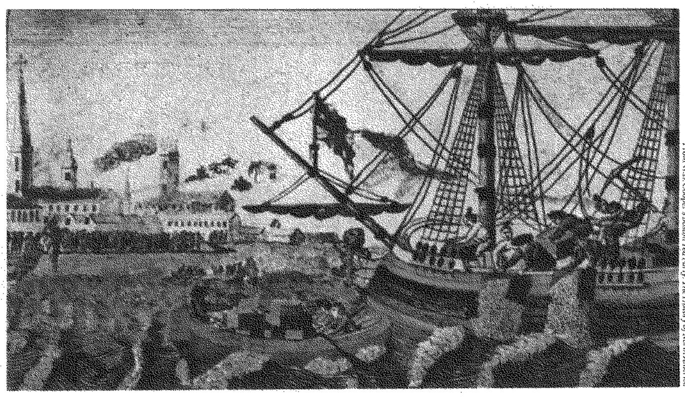
enacted a series of punitive Coercive Acts (called "Intolerable Acts" by the colonists), including an attempt to limit town meetings such as those held in Faneuil Hall.[16]

Two hundred years after the Declaration of Independence, Faneuil Hall was still used as a place for meetings and other events, but its commercial uses had been discontinued. A 1976 renovation restored the building to its central role in Boston life and served as a model for renewal and revitalization in other American cities. Today Faneuil Hall still houses public forums and serves as the anchor of a robust and vital commercial center.

The City of Boston is highly aware of the dangers posed by sea level rise and heavier rains, and is proactive in planning resilience strategies.[17] The Organisation for Economic Co-operation and Development (OECD) ranked Boston the eighth-highest metropolitan area worldwide in expected economic losses, estimated at $237 million per year between now and 2050, due to coastal flooding.[18] In a 2013 report, the Boston Harbor Association noted that if Hurricane Sandy had hit just five or six hours later, at high tide instead of low tide, more than 6 percent of the city would have been under water.[19] A flood of that magnitude would inundate many of Boston's coastal neighborhoods, including 65 percent of the Fort Point Channel and Blackstone Block historic districts.[20] As the sea level continues to rise, the risk of major coastal flooding increases.

During the winters of 2013 and 2014, nor'easters caused storm tides to rise even higher than those from Hurricane Sandy in 2012—one rose a foot higher.[21] Yet so far Boston has been lucky, as these storm surges have all coincided with low tides.[22] If the worst of the storm surges had hit at high tide, major flooding could have occurred, inundating much of the waterfront, past Faneuil Hall up to City Hall, and the part of the North End where Paul Revere began his ride.[23]

Boston officials know that they can't depend on this good fortune to continue indefinitely. Because of sea level rise and other climate threats, including higher temperatures and increased smog, the city has embarked on major initiatives to address climate change mitigation and adaptation. Boston has improved its emergency warning systems for flooding, high winds, and winter storms. All new municipal construction must include both an evaluation of climate risks through the year 2050 and a description of ways to avoid, minimize, or mitigate those risks. Other measures include deploying "green" infrastructure (which uses vegetation and soil to manage rainfall and reduce urban heat), better enforcement of flood-proofing building standards, and preparedness for addressing a variety of hazards such as floods, hurricanes, and extreme heat before they occur.[24]



From W.D. Cooper's *Boston Tea Party: The History of North America*

A cartoon of the Boston Tea Party from 1789. The City of Boston is protecting its share of national treasures, some of which are located near the waterfront, by improving its emergency warning systems for flooding, requiring all new municipal construction to evaluate climate risks through 2050, and better enforcing flood-proofing building standards, among other measures.

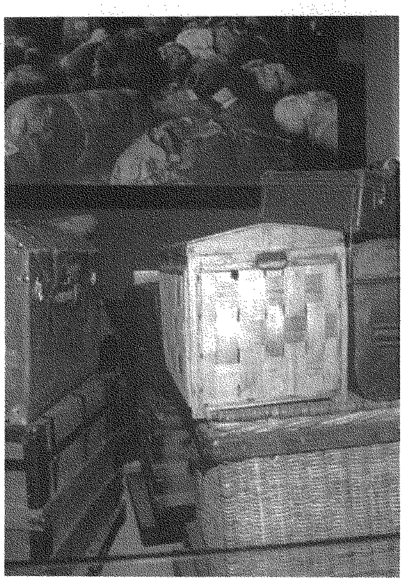
Protecting the Statue of Liberty and Ellis Island from Rising Tides

The Statue of Liberty and Ellis Island, prominently positioned in New York Harbor and serving as a gateway to our nation's largest city, are powerful symbols of freedom and democracy. Each year, millions of tourists visit these monuments to trace their family ancestry or explore the immigration experience so central to the American identity.[26]

Those visits came to a halt on October 29, 2012, when Hurricane Sandy submerged most of Liberty and Ellis islands, destroying vital operating systems and causing an estimated $77 million in damage.[27] It took many months of recovery efforts before they reopened to the public in 2013. Even then, repairs were still under way to protect Ellis Island from future storms,[28] whose surge of piled-up water will be magnified by rising seas.

Nearly 14 million immigrants entered the United States through New York between 1886 and 1924. The Statue of Liberty with its raised torch, famously called "The Mother of Exiles," welcomed them as they sailed into port.[29] The vast majority of newcomers were processed at nearby Ellis Island, which was the country's largest immigration station. Until 1954, when it officially closed, 12 million immigrants stepped onto American soil for the first time at Ellis Island. For most of these new arrivals, the island marked the beginning of a new life in the United States, one filled with the promise of economic opportunity and freedom from persecution.[30]

But while Liberty Island (upon which the Statue of Liberty stands) and Ellis Island have long represented a safe refuge for generations of immigrants, the islands themselves were not protected from the ravages of Hurricane Sandy.[31] A massive storm unlike any experienced before in New York, together with rising sea levels primarily due to climate change, caused



© Americanspirit/Dreamstime.com

Hurricane Sandy forced the National Park Service to move more than a million treasured artifacts—such as Native American pieces dating back to 783 A.D., personal belongings of immigrants (above), and architectural drawings—off Ellis Island for safekeeping.[32,33]

© NPS Tab

Hurricane Sandy's massive storm surge destroyed most of the radio equipment, electrical infrastructure, and security systems of both Liberty and Ellis Islands. Floodwaters inundated three-quarters of Liberty Island—some of the aftermath is pictured, above—and the beloved landmark was closed to the public for more than eight months.[34]

floodwaters to inundate three-quarters of Liberty Island and almost all of Ellis Island.[35,36,37]

Liberty Island was closed for more than eight months and Ellis Island partially reopened a full year after the storm, with sections of the historic main building and museum, including most of their exhibits, remaining closed.[38] Statue Cruises, the company that runs ferries to the two islands as well as harbor tours, saw its annual ridership of nearly 4 million drop by more than half, lost 80 percent of its overall revenue, and had to lay off 75 percent of its workforce during the closures.[39]

Hurricane Sandy also marked the end of a 200-year tradition of people living on Liberty Island. The National Park Service (NPS) decided not to rebuild the small brick house located on the lowest part of the island—home to the park's superintendent—because of the danger of placing residents in the path of future flooding.[40]

Previous coastal storms have hit New York with higher winds and more rain than did Hurricane Sandy, but the storm surge it created was unprecedented. Sandy coincided with a higher-than-normal high tide in the Atlantic Ocean and in New York Harbor, given the alignment of the sun and moon at the time. In addition, the storm was 1,000 miles wide, more than three times the size of Hurricane Katrina, which devastated the Gulf of Mexico coast in 2005.[41]

> [***Hurricane Sandy's storm surge rode in on sea levels that had risen by more than a foot and a half since the 1850s, leading to more widespread coastal flooding.***]

Making matters worse, sea levels in the New York area had risen by more than a foot and a half since measurements began in the 1850s,[42] leading to higher and more widespread coastal flooding. There is evidence as well that Sandy gained strength from unusually warm upper-ocean temperatures in the North Atlantic; these temperatures are expected to continue rising with global warming.[43,44]

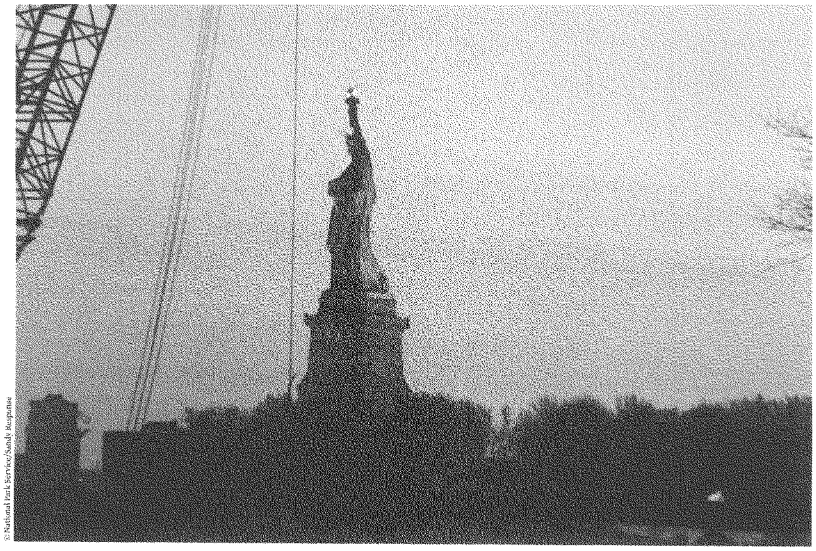
"Clearly, while Sandy was historic, it was not, in fact, a worst-case scenario for all of New York City. And as the climate changes... the risks that New York City faces will only intensify." So concluded *A Stronger, More Resilient New York*, a plan released in June 2013 that recommended investments for protecting the city from the impacts of climate change.[45]

In a preface to the plan, then-Mayor Michael Bloomberg noted that the city had already been preparing when Hurricane Sandy hit, "but the storm set the bar higher," he said. "As the possibility of more severe weather increases with climate change, we must rise to the occasion."

The NPS is also preparing for the possibility that Liberty Island and Ellis Island may again be in harm's way. In working to make these monuments more resilient to future storms, the agency's rebuilding efforts include elevating their electrical systems as much as 20 feet above sea level and designing the heating and air conditioning systems to withstand flooding.[46]

Like New York City, the NPS was already developing nationwide guidelines to identify and manage the risks posed by climate change, particularly regarding its coastal properties. But then Hurricane Sandy struck, making the need to develop and implement a robust adaptation strategy all the more urgent.[47]

"We recognize that these climate change stressors are real," says Shawn Norton, the NPS bureau chief for the Sustainable Operations and Climate Change Group, "and they are going to become more common and intense."



© National Park Service/Sandy Response

The relighting of Liberty's torch after Hurricane Sandy, above, is now a symbol not only of freedom but also of resiliency in the face of rising seas and stronger storms. New York City and the National Park Service are preparing for the possibility that Liberty Island and Ellis Island may again be in harm's way.[48,49]

Monument to Harriet Tubman's Legacy Is Vulnerable to Rising Sea Levels

By commemorating the life of the legendary abolitionist, renowned for her courage and determination, the Harriet Tubman Underground Railroad National Monument promises to instill in visitors a deeper understanding of the African-American experience of slavery and hard-won freedom.

On March 25, 2013—the centennial of Tubman's death—President Barack Obama designated 25,000 acres on Maryland's Eastern Shore as one of the nation's newest monuments.[50] But this embodiment of Tubman's antislavery legacy may be endangered by sea levels in the Chesapeake Bay, which have risen at almost twice the global rate because of climate change.[51,52] The site could be largely underwater by 2050.[53]

This imperiled land in Dorchester County is where Tubman was born into slavery in 1822 and toiled under oppressive masters, whose beatings caused her to suffer from chronic seizures throughout her life. She eventually escaped, at age 27, only to return to Maryland numerous times to rescue others and lead them north through thick weeds and marshes to freedom. This delivery of a great many of her people from bondage, via the network of secret routes and safe houses known as the Underground Railroad, earned her the nickname "Moses."[54]

"Harriet Tubman's story is America's story. She risked her life over and over again in the struggle against the evil of slavery. She lived by principles, strong faith in God, her love of family, and a belief in a better life," said Chérie A. Butler, the National Park Service's superintendent of the Tubman monument. "Ms. Tubman's story is a testament that one determined person—no matter [her] station in life—can make a difference."

The new monument fulfills the aspirations of many supporters who spent years pressing for a landmark to honor

©H. Seymour Squyer

Harriet Tubman (above, ca. 1885), the "Moses of her people," led dozens of enslaved people to freedom through lands that now form one of the nation's newest monuments. But these marshes, some of which are now part of the Blackwater National Wildlife Refuge, are being lost to the rising ocean at an alarming rate and could be underwater by 2050.[55]

© Jay L. Baker

Federal, state, and local officials participate in the groundbreaking for the new Harriet Tubman Underground Railroad National Monument. Left to right: Harriet Tubman Organization President David Pinder, Maryland Department of Natural Resources Secretary John Griffin, National Park Service Director Jonathan Jarvis, Cambridge Mayor Victoria Jackson, Maryland Park Service Superintendent Nita Settina, Governor Martin O'Malley, U.S. Department of the Interior Secretary Ken Salazar, Councilman William Nichols, Maryland Secretary of General Services Alvin Collins.

[*The visitor center will be built on higher ground, and architecturally elevated, in recognition of the threat posed by rising sea levels.*]

Tubman's legacy as an abolitionist, nurse, and spy for the Union Army during the Civil War. A 2012 letter to the Department of the Interior requesting the national-monument designation was signed by a bipartisan group of lawmakers that included the state's Republican Representative Andy Harris and Democratic Senators Ben Cardin and Barbara A. Mikulski.[56]

This achievement, however, may not be long-lived. Maryland, with more than 3,000 miles of tidal shoreline and low-lying rural and urban lands, is one of the states most vulnerable to sea level rise.[57] Designating Tubman's birthplace a national monument protects it from development but not from the rising seas off Maryland's coast. Already, the waters of the Chesapeake Bay near the Tubman memorial have risen more than 10 inches over the past 70 years and may rise another 15 inches by 2050.[58,59]

The Tubman monument is a vast expanse of marshes, fields, and forestlands that today remain much the same as when Tubman was alive.[60] This status could change in the coming decades, as warming oceans increase the likelihood that tropical cyclones that survive the formation process will become Category 3, 4, or 5 storms—with the western North Atlantic (which abuts Maryland, among other states) being hit especially hard.[61] Powerful storm surges riding on higher sea levels will be able to penetrate farther inland, causing more damage to the shoreline than the region has experienced for thousands of years.[62]

Just weeks before the president announced the monument, Maryland broke ground on the 17-acre Harriet Tubman Underground Railroad State Park, which falls within the boundaries of the national monument and is expected to open in 2015 at a cost of $21 million.[63] Construction is under way on a 15,000-square-foot visitor center, designed with state-of-the-art systems for energy and water efficiency. Moreover, the center will purposely be placed on higher ground, and elevated as well, in recognition of the threat posed by rising sea levels.[64]

But these measures may not be enough. The Tubman monument includes parts of the Blackwater National Wildlife Refuge, where wetlands at sea level are being lost to the rising ocean at the rate of about 300 acres a year.[65] A 2002 study by the U.S. Geological Survey predicted that the refuge could be underwater by 2050—a loss that would deprive nearby communities of the critical protection against storms and sea level rise that the wetlands provide.[66] This area also is home to one of the largest populations of nesting bald eagles on the Atlantic coast, as well as to numerous other bird and mammal species.[67]

Efforts to limit sea level rise by reducing carbon emissions, as well as large-scale projects to restore wetlands, will be necessary to ensure that this landscape remains not only an important national symbol—of our country's checkered history of securing civil rights for all of its people—but also that it remains a vital part of the economy of Maryland's Eastern Shore.

©Steven L. Tabone Nature Photographic

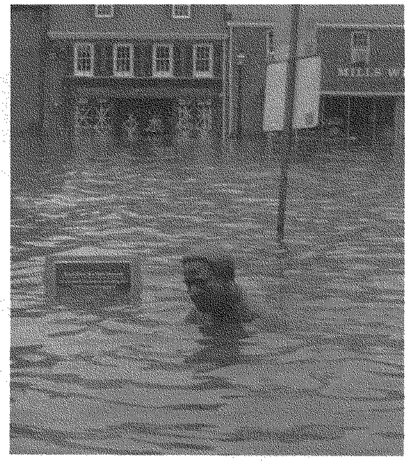
The Tubman monument is a vast expanse of marshes, fields, and forestlands known so well by Tubman that she used these natural landmarks as navigational tools on the Underground Railroad's route to freedom. But these marshes are being lost to the rising ocean at an alarming rate and could be underwater by 2050.[68]

Planning to Prevent Storm Damage in a Historic Colonial Town

The next major storm that hits Annapolis, MD, could cause extensive flooding and widespread damage to the city's historic center. Because sea levels continue to rise in Chesapeake Bay, a so-called 100-year storm (a severe event with a 1 percent chance of occurring in any given year) would likely severely damage many historic structures in Annapolis, take years from which to recover, and seriously harm the city's tourism economy.[69]

Laid out in 1695, Annapolis was one of the first planned cities in the United States. Its historic core contains the country's largest concentration of eighteenth-century brick buildings, including the Palladian-style Hammond-Harwood House, widely regarded as one of the finest colonial buildings in America.[70] Settled in the mid-seventeenth century by nonconforming Protestants from Virginia and other religious independents, Annapolis later became the capital of the colony, and the state, of Maryland. The city's eighteenth-century waterfront bustled with ships bringing visitors, immigrants, servants, and slaves to town. Imported goods from Europe, the Caribbean, and other colonies filled dockside warehouses.[71]

All four of Maryland's signers of the Declaration of Independence lived in Annapolis at one time or another, and the city was the first post-Revolutionary War capital of the United States, hosting the Continental Congress in 1783 and 1784. George Washington resigned his commission as commander of the Continental Army here in 1783, and the Treaty of Paris, which formally ended the war, was ratified in the State House in 1784. That building's huge wooden dome—the largest in the nation—became a model in subsequent years for many other American state houses.[72]



©Alexis Bond

This Annapolis statue, commemorating Roots *author Alex Haley and his central character Kunta Kinte, is shown here during Hurricane Isabel in 2003. Isabel's storm surge also caused disastrous flooding in the historic City Dock area, damaging dozens of buildings.*[74]

Annapolis is also known as the home of the U.S. Naval Academy. Founded as the Naval School in 1845, with an initial enrollment of about 50 students, most of its Beaux Arts–style historic buildings date from the early 1900s, including the chapel with its iconic dome. The body of John Paul Jones, one of the founding officers of the Continental Navy, lies in a crypt under the chapel.[73] The famous flag carrying the words "Don't give up the ship," flown in 1813 by Admiral Oliver Hazard Perry at the Battle of Lake Erie, hangs in Memorial Hall.

Many of the places and structures that provide daily reminders of Annapolis's rich history are today at risk because sea levels along the coast of Maryland are rising. During the last 20 years, sea level along the 620-mile Atlantic coastline north of Cape Hatteras, NC, has risen up to four times faster than the national average.[75] According to scientists at the University of Maryland, Chesapeake Bay's sea level could rise by another one to two and a half feet by the middle of this century.[76] To make matters worse, warmer ocean temperatures are fueling stronger North Atlantic hurricanes.[77] Storm surges associated with hurricanes and other storms have caused the water to ascend three feet or more above mean sea level at least 10 times in Annapolis during the last decade.[78,79] Resulting damage can be expected to worsen in the future, as rising seas not only raise the frequency of floods from regular high tides but also increase the height of storm surges.[80]

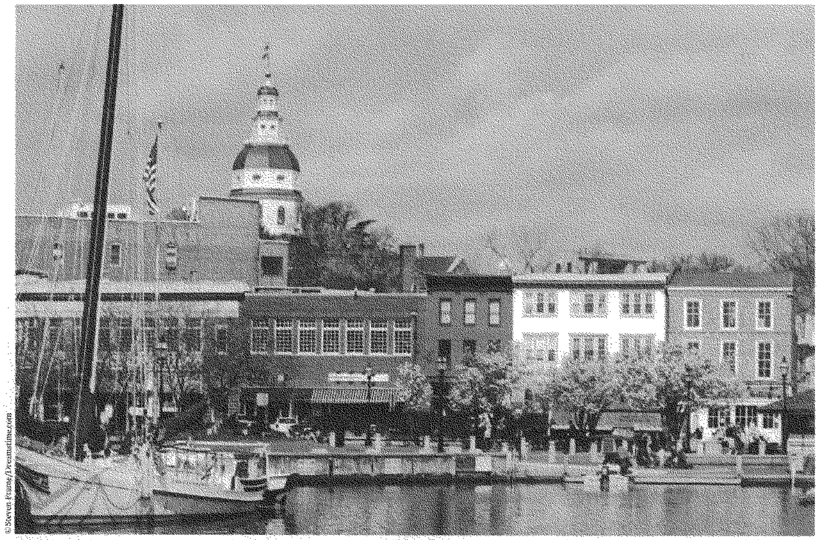
Tropical cyclones and nor'easters can bring powerful winds that push waters up against the head of Chesapeake Bay,[81] potentially causing catastrophic flooding in Annapolis. Hurricane Isabel caused widespread and serious flooding in the city during September 2003, when water levels at the Naval Academy reached about six and a half feet above average, more than two feet over the current 100-year flood level; classrooms, laboratories, athletic facilities, residence halls, and the utility tunnels under the Nimitz Library were inundated, causing more than $120 million in damage.[82,83] Since Hurricane Isabel, the Naval Academy has developed extensive flood-mitigation plans and implemented many measures to reduce damage and bolster resilience to future floods.[84] Measures have included the installation of door and window dams, temporary flood walls, and check valves on tunnels. Belowground cisterns that capture storm water and slowly release it have been built to mitigate the impacts of flooding.

The storm surge from Isabel caused disastrous flooding in the historic City Dock area too, damaging dozens of buildings. It took a decade before the 1858 Market House was restored, reopening in 2013.[85]

In addition to the threat of major storms, regular nuisance flooding in Annapolis is increasing as a result of sea level rise.[86] Seven of the highest water levels since 1937 have

© Cherie A. Thurlby, U.S. Department of Defense

Although hats were tossed high during this graduation ceremony at the U.S. Naval Academy, the mood during Hurricane Isabel was far from festive. Water levels at the time were more than two feet over the current 100-year flood level, causing more than $120 million in damage to the campus.[87,88]



©Steven Frame/Dreamstime.com

To help protect historic shops and buildings along the waterfront in downtown Annapolis, the city is developing a Cultural Resource Hazard Mitigation plan, which is likely to become a model for other historic coastal cities facing sea level rise, higher storm surges, and more frequent coastal flooding.[89]

occurred since 2000.[90] Most of the area around City Dock is at just two to four and a half feet above sea level, and minor flooding begins when water levels reach 1.9 feet. At that point, storm drains begin to back up and water discharges from drain inlets.[91]

The city is preparing for the inevitability of another major storm and, by 2050, for at least a doubling of high-tide flooding events.[92] In order to ensure the preservation of the buildings and streetscape within the 100-year floodplain of the city's Historic Landmark District, Annapolis is developing a Cultural Resource Hazard Mitigation plan—beginning with a comprehensive survey of all 140 at-risk buildings in the district—supported in part by the National Trust for Historic Preservation, the Maryland Historical Trust, and Preservation Maryland.[93] Among the many important buildings close to the City Dock that the survey will include are the waterfront Tobacco Warehouse (early nineteenth century); Middleton Tavern (ca. 1750), from which renowned visitors including George Washington and Thomas Jefferson traveled by ferry across the bay; and the Sands House (ca. 1739), one of the city's oldest and lowest-lying buildings. Annapolis's pioneering approach to minimizing damage and disruption from future climate change is likely to become a model for other historic coastal cities.

> ***[Many of the places and structures that provide daily reminders of Annapolis's rich history are today at risk because sea levels along the coast of Maryland are rising.]***

[HISTORIC JAMESTOWN, VA]

Rising Seas Threaten to Inundate Jamestown Island

© Americanspirit/Dreamstime.com

Jamestown commemorates the first permanent English colony in what is now the United States with the tercentenary monument, the John Smith memorial (both pictured above), archaeological sites, and irreplaceable artifacts. Hurricane Isabel damaged just under a million of Jamestown's artifacts, which had to be hand-dried to prevent mildew and rot.[94]

By the end of this century, the only way to experience "America's birthplace" may be by reading about it in history books or online. That's because rising sea levels and increasingly powerful coastal storm surges could submerge much of Virginia's Jamestown Island—the site of the first permanent English colony in North America—and could carry away much of its buried treasure of centuries-old artifacts.[95,96]

Virtually all of the land where Pocahontas and Captain John Smith once walked is now less than five feet above water,[97] and this small margin is slipping lower as increasingly severe storm surges and flooding erode the shoreline.[98,99] To make matters worse, the land is sinking, partly because of groundwater extraction.[100]

Despite efforts to protect Jamestown, scientists and park officials have been sounding ever-louder alarms that saving it may not be possible in an era of climate disruption.

Valued by Americans as the origin of the country's representative democracy, Jamestown is part of the Colonial National Historical Park, which also includes Yorktown—where the last major battle of the American Revolutionary War was fought. Some 3 million visitors a year use the 23-mile scenic Colonial Parkway that connects many of the park's historic sites;[101] according to the National Park Service (NPS), in 2011 these visitors injected an estimated $62.6 million into the local economy.[102]

The waters surrounding Jamestown have been rising at a rate of more than twice the global average,[103,104] and this local rate is bound to increase with the melting of land-based ice (such as the Greenland and Antarctic ice sheets), as a result of the warming global climate.[105] Projections by the Virginia Institute of Marine Science are that the state's coastal waters could rise as much as two feet by 2050 and up to six feet by the end the century.[106]

Warmer ocean temperatures mean that when North Atlantic storms survive the hurricane-formation process, they often are rendered stronger than at lower temperatures.[107,108] In 2003, Hurricane Isabel demonstrated the destruction that even a Category 2 hurricane could inflict on this vulnerable area. The national park sustained $20 million in damages when Isabel struck at high tide, producing heavy rainfall and creating one of the highest storm surges on record in the Chesapeake Bay region; thousands of trees were uprooted and lower elevations were flooded. Before Isabel hit, the NPS had already decided to build a new visitor center on a higher elevation, but not soon enough; the existing center and its museum were badly damaged in the storm.[109]

The park's artifacts and archaeological sites are precious and irreplaceable; among other things, they help us better understand the lives of the early settlers and the Native Americans who preceded them. That is why Isabel's damaging of just under a million of Jamestown's artifacts, which had to be evacuated and then hand-dried to prevent mildew and rot, was such a wake-up call.[110] The flooding also submerged the remains of the original furnaces of a 400-year-old glassblowing factory—one of the earliest industrial sites in North America—and almost wrecked a nearby replica, where present-day artisans fashion wine bottles and candleholders using colonial methods.[111]

© Smithsonian Institute

Forensic anthropologist Douglas Owsley (left) and APVA Preservation Virginia/ Historic Jamestowne archaeologist Danny Schmidt discussing the double burial of two European males. The site's treasures are so imperiled that archaeologists are rethinking the practice of keeping artifacts still buried in the ground for discovery by future generations.

The NPS is now working to protect Jamestown's resources and ensure that Americans can continue to visit its historic sites. Riprap (a breakwater made from large stones) has been installed around most of Jamestown to prevent future shoreline erosion. The original Jamestown Fort, owned and managed by Preservation Virginia, is being excavated, even though one corner of the fort has already been lost. And the NPS also is monitoring the local rate of sea level rise and planning additional research to determine how Jamestown might further adapt to this and other impacts of climate change.[112]

[FORT MONROE NATIONAL MONUMENT]

Freedom's Fortress Is at Risk from Higher Seas and Heavier Rains

Rising seas and heavier rainfall are threatening an iconic place—Fort Monroe, VA—in the centuries-old struggle for liberty and justice in America. This imposing fort, perched on low-lying Old Point Comfort at the mouth of Chesapeake Bay, played a pivotal role in bringing an end to American slavery on the very spot that also had witnessed slavery's beginning. President Obama recognized Fort Monroe's extraordinary history when he designated the site a national monument in 2011.[113] But now the Virginia fort that served as a beacon of freedom to escaping slaves needs protection itself—from rising water levels and increasingly severe flood damage caused by climate change.

On the night of May 23, 1861, just hours after the ratification of Virginia's secession from the Union, three young enslaved people—Sheppard Mallory, Frank Baker, and James Townsend—rowed across the waters of Hampton Roads to Union-held Fort Monroe in search of freedom. The three men had escaped from a work detail that was building Confederate defenses at nearby Sewell's Point. Soon afterward, when a Confederate officer arrived to demand the return of the fugitives, Fort Monroe's newly arrived commander, General Benjamin Franklin Butler, made a decision that would eventually lead to President Abraham Lincoln's Emancipation Proclamation. He refused to return the men, on the basis that they were "contraband of war."[114]

Word of the "contraband" decision spread quickly across the slave states, and soon a flood of escapees began flocking toward Union camps and forts, all seeking liberty. Many volunteered to help the Union cause as soldiers, scouts, and laborers. The courage of these men, women, and children led Congress to pass a series of laws that guaranteed their freedom—and that cleared a path for the president to issue his Emancipation Proclamation.[115]

© Jason Portell

Under this tree, Mary Peake taught children from the "contraband camp." In 1863, people gathered here for the first Southern reading of the Emancipation Proclamation. The Emancipation Oak still stands on the grounds of Hampton University.[117]

As space in and around Fort Monroe began running out, Great Contraband Camp, one of the first self-contained African-American communities in the country, sprang up in the burned-out ruins of Hampton. In 1861, a free black woman, Mary Peake, began teaching classes in the shade of a spreading oak tree, where in 1863 the first Southern reading of the Emancipation Proclamation would be heard. Peake's makeshift schoolroom evolved into Hampton University, one of the nation's first historically black colleges. Today, the Emancipation Oak still stands on the campus, a symbol of the promise of education for all.[116]

© Virginia Tourism

Fort Monroe, VA, at the mouth of Chesapeake Bay, was integral to the end of American slavery. The first African slaves to arrive in English North America made landfall at Old Point Comfort where the fort now sits; 250 years later, "Freedom's Fortress" provided refuge for thousands of escaping slaves during the Civil War.[118,119]

Fort Monroe was also the setting of an earlier chapter in the history of American slavery. In 1609, soon after the English settlers first arrived at Jamestown, they built a defensive outpost at Old Point Comfort, the site of Fort Monroe, and it was here that in 1619 the first African slaves to arrive in English North America made landfall.[120] Thus across the span of some 250 years, this small spit of land witnessed both the beginning and the end of American slavery.

Fort Monroe is highly vulnerable to sea level rise and coastal flooding. A nearby tide gauge shows that water levels near the fort have risen almost a foot and a half since the 1920s.[121] A study for the Virginia General Assembly projects the state's coastal waters could rise as much as another two feet by 2050 and up to six feet by the end the century.[122] With a higher sea level, coastal storm surges—the potentially destructive increases in sea height that occur during a coastal storm—could inundate areas much farther inland. In addition to the rising sea, since 1950 the area around Fort Monroe has also experienced significantly more heavy-rainfall events than before.[123]

> ***Fort Monroe is highly vulnerable to sea level rise. A nearby tide gauge shows that water levels near the fort have risen almost a foot and a half since the 1920s.***

The combination of rising sea levels and heavier precipitation will likely increase the frequency and severity of flooding at Fort Monroe. The tide gauge at Sewells Point measured storm surges of more than four and a half feet during Hurricane Irene in 2011 and over five and a half feet during Hurricane Isabel in 2003.[124] Hurricane Isabel caused more than

$100 million in damage at Fort Monroe,[125] with nearly 200 housing units and administrative buildings damaged by floodwaters and several wooden piers destroyed.[126]

After Isabel, the Army Corps of Engineers built a new seawall, but in so doing it took into account only the historic rates of sea level rise, not the higher rates that Hampton Roads is likely to experience from now on.[127] Already, flooding events triggered by storms and exceptionally high tides regularly inundate basements and cause untreated sewage to flow directly into Chesapeake Bay.[128] One recent study found that among the highest tides recorded at Sewells Point between 1930 and 2010, half of them occurred in the last 13 years of the study period.[129]

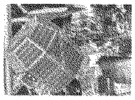
© Peter Stinson

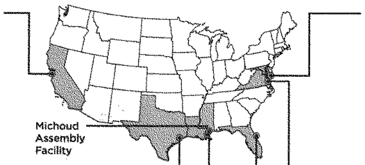
Surrounded by the Atlantic Ocean, Fort Monroe is vulnerable to flooding from rising seas, storm surge, and extreme precipitation. Hurricane Isabel's storm surge of five and a half feet (2003) caused more than $100 million in damage to housing units, administrative buildings, and wooden piers.[130,131]

Multiple NASA Sites Face Challenges from Rising Seas

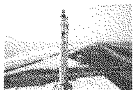
FIGURE 2. NASA Coastal Facilities

Ames Research Center, *Moffett Field, near San Francisco, CA. Some of NASA's most vexing challenges have been tackled at this research center known for its innovative problem-solving—such as how to shape vehicles to withstand the extreme heat of reentry into Earth's atmosphere.*

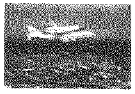




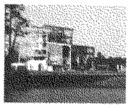
Wallops Flight Facility, *along the Eastern Shore of Virginia. Wallops hosts six launch sites and support facilities; more than 16,000 rockets have been launched from this island since 1945.*



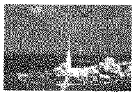
Johnson Space Center, *on Galveston Bay near Houston, TX. This is NASA's command center for human spaceflight operations and is home to the Apollo Mission Control Center, designated a national historic landmark. All U.S. astronauts train at this facility.*



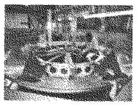
John C. Stennis Space Center, *Hancock County, MS. Launch vehicles used in the Apollo moon landing program and the main engine for the space shuttle were tested here. At a sister site in Louisiana, the Michoud Assembly Facility contains one of the largest production buildings in the country.*



Kennedy Space Center, *Cape Canaveral, FL. Deeply embedded in the American imagination, the Apollo moon missions and many space shuttle missions were launched from this site. The launch pad is very close to the ocean and is vulnerable to the dangers of rapidly rising seas and storm surge.*



Langley Research Center, *Hampton, VA. Langley boasts a well-earned reputation as a leader in the history of flight technology. This complex houses facilities for simulating flight, including a wind tunnel for testing at supersonic speeds.*



For three generations, the National Aeronautics and Space Administration (NASA) has stirred humans to think beyond our home planet and ponder our place in the universe. From the sight of the first people landing on the moon in 1969 to the awe-inspiring beauty of the cosmos beamed back as images from the Hubble Telescope, NASA has inspired us. But with more than two-thirds of its facilities within 16 feet of sea level, and many launch pads and other structures at very low elevations,[132] NASA faces urgent challenges to protect itself from rising seas.

When the Soviet Union launched Sputnik, the first successful artificial satellite, in 1957, Americans were shocked at losing the first phase of the space race to their cold war rival, yet they were also exhilarated by the potential of space exploration.[133] Impelled by this competition, NASA executed a series of manned space missions: Projects Mercury, Gemini, and Apollo.[134,135,136] Further propelled by Soviet cosmonaut Yuri Gagarin's first human flight into outer space, President John F. Kennedy vowed in 1962, "We choose to go to the moon in this decade."[137] And indeed, on June 20, 1969, Buzz Aldrin and Neil Armstrong became the first men to land on the moon, thrilling their fellow Americans as they walked on its surface for more than two hours and planted the Stars and Stripes.[138] At the height of the cold war, NASA embodied American courage and innovation and spurred the country to higher scientific achievement.

Since the moon landing, NASA has carried out hundreds of missions, manned and unmanned, including the launch of a prototype space station (Skylab, in 1973).[139] For 30 years, from 1981 to 2011, as the cold war waned and ended, the Space Shuttle Program solidified international cooperation in space.[140] In 1990, NASA launched the Hubble Space Telescope, which takes extremely high-resolution images of deep space—and therefore of the universe's past.[141] The agency has made unmanned explorations of all the planets in our solar system, sampling ice on Mars,[142] confirming temperatures on Venus,[143] and discovering methane lakes on Saturn's moon, Titan, and a possible subsurface ocean on Jupiter's moon, Europa.[144,145] NASA's Hubble, Chandra, and Fermi observatories have revealed that enormous black holes, present in most galaxies, often emit powerful jets of matter traveling near the speed of light, thereby allowing physicists to test Einstein's theories.[146,147]

NASA yielded its launch of commercial satellites to the private sector in 1986,[148] but it continues to launch resupply rockets for the International Space Station and other scientific satellites and instruments. Such space tools allow scientists to study the atmosphere and oceans in great detail, provide farmers with weather forecasts that guide them on when to plant and harvest, and help government and industry alike to improve aviation safety and shipping reliability.[149,150] In October 2012, NASA's space tools enabled predictions that Hurricane Sandy would make landfall in southern New Jersey nearly five days before the storm hit. As devastating as the hurricane was, the accuracy of these predictions meant that officials and citizens could make life-saving decisions about preparedness and evacuation.[151]

In the area of the environment, NASA's Goddard Institute for Space Studies undertakes research on natural and man-made changes that "affect the habitability of our planet," while the agency's Goddard Space Flight Center runs the satellites that study climate.[152,153] It is ironic that the agency that has done so much to warn us about climate change, and to prepare us for the resulting disruptive weather, itself faces challenges from rising seas and other climate-change impacts.

Wallops Flight Facility

For example, NASA's Wallops Flight Facility, along the Eastern Shore of Virginia, has completed more than 16,000 rocket launches since its establishment in 1945. Billing itself as the "on-ramp to the International Space Station," Wallops hosts six launch sites as well as support facilities and a major Naval Surface Combat Systems Center. According to NASA's own climate-adaptation planning documents, Wallops is critical

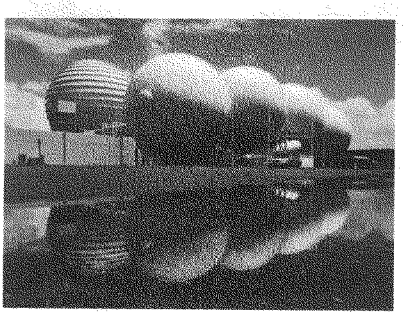
© Stephen Nakatani

Rockets are still being launched from NASA's Wallops Flight Facility in Virginia (above, 2013), but it's unclear how long this island facility can withstand higher seas, which have risen by more than nine inches in less than 70 years.

to these missions because it is geographically secluded and adjoins the Atlantic Warning Area, a secure airspace with no commercial traffic.[155] But as of 2013, sea level had risen by more than nine inches since the facility opened.[156] In response, NASA has built seawalls to protect the facility, and in August 2012 the agency completed a dune-building project that added more than 3 million cubic yards of sand.[157,158] Such precautions, however, were insufficient against Hurricane Sandy, which removed about 700 feet of a protective sand barrier, 20 percent of the beach between Wallops and the sea, and damaged the facility's roofs, siding, and other infrastructure.[159]

Langley Research Center

According to Tom Crouch, an aviation historian at the Smithsonian Institution, "No place has played a larger role in the history of… flight technology… than Langley Research Center" in nearby Hampton, VA.[160] In this $3.5-billion complex, NASA has specialized facilities for simulating flight, including a wind tunnel for testing in the supersonic speed range and a one-of-a-kind transonic dynamics tunnel that tests aeroelasticity and flutter.[161] However, many of these facilities are already vulnerable to sea level rise and coastal storms. During Hurricane Isabel in 2003, the storm surge was almost five and a half feet above normal high tides.[162] Langley was closed for a week, with much of its eastern area flooded by two feet of water.[163]

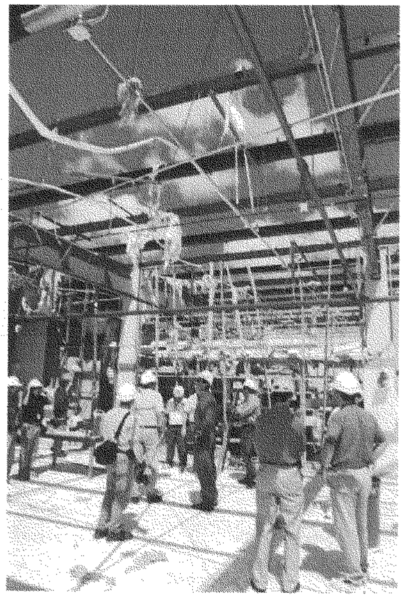


© NASA/David C. Bowman

NASA-Langley, with its vacuum spheres (above), holds a venerated position in this country's history of flight, but its reputation is no match for ongoing sea level rise and stronger coastal storms. Hurricane Isabel's (2003) storm surge—almost five and a half feet above normal high tides—closed Langley for a week.[164,165]

Kennedy Space Center

The Apollo missions that reached the moon, and many missions of the space shuttle, were launched from the Kennedy Space Center at Cape Canaveral, FL. But according to its planning and development office, rising sea levels are the single largest threat to the center's continued operations because they threaten launch facilities and transportation corridors, among other mission-critical infrastructure.[166] Storm surges regularly breach the dunes near the launch pads, and while NASA has undertaken several efforts to protect and restore the dunes, few of these attempts have survived subsequent storms.[167]



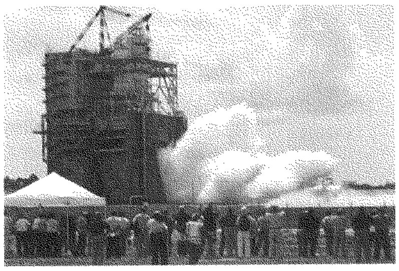
© NASA

Members of a hurricane assessment team observe the damage to the roof of the Thermal Protection System (TPS) Facility at Kennedy Space Center after Hurricane Frances (2004). The facility, which created the TPS tiles, blankets, and all the internal thermal control systems for the space shuttles, was almost totally unserviceable after losing approximately 35 percent of its roof.[168]

John C. Stennis Space Center & Michoud Assembly Facility

The John C. Stennis Space Center, in Hancock County, MS, was the test site for launch vehicles used in the Apollo moon landing program, and the main engine for the space shuttle was tested here in 1975.[169] About 50 miles away, in Louisiana, is the Michoud Assembly Facility, which contains one of the largest production buildings in the United States and which supports the next generation of space transportation vehicles.[170] The areas along the coasts of Louisiana and Mississippi near Stennis and Michoud are experiencing sea level rise up to five times the global average because while the seas are rising, the land is also subsiding.[171] Further, because the waters just below and at the surface of the Gulf of Mexico are warmer than they used to be, when hurricanes occur they have a greater chance of becoming stronger—as did Hurricane Katrina.[172]

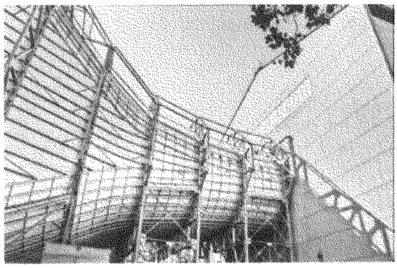
When Hurricane Katrina hit in 2005, Stennis and Michoud together experienced estimated damages of some $760 million.[173] Most of those costs were incurred at Michoud, where a shuttle-manufacturing plant was severely impacted, though a "ride-out" crew of 37 operated pumps around the clock to protect the factory from catastrophic damage.[174] Following the storm, about 25 percent of Stennis's employees had uninhabitable homes or no homes at all, and the I-10 bridge, which provides main highway access between New Orleans and Stennis, was torn apart.[175]


© NASA

NASA facilities at the John Stennis Space Center (MS) and the Michoud Assembly Facility (LA) are experiencing sea level rise up to five times the global average because while the seas are rising, the land is also subsiding.[176] The above photo shows operators conducting the last space shuttle main-engine test in July 2009.

Ames Research Center

NASA's Ames Research Center (Moffett Field, CA) has long had a reputation for hatching NASA's most innovative small projects. For example, in 1951 director H. Julian Allen solved the vexing problem of how to shape vehicles to withstand the extreme heat of reentry into Earth's atmosphere. He developed the revolutionary "blunt body theory," which allowed astronauts to return safely from Mercury, Gemini, and Apollo missions.[177,178] But today the center's own safe operation is being threatened as it experiences increasingly intense storms, some of which have flooded underground installations, caused power loss, and closed runways.[179,180] In 2010, parts of buildings were rendered uninhabitable for weeks by rapidly growing mold.[181] Even modest sea level rise may mean that lighter rainfalls could flood Ames's facilities in the future.[182]


© Photobuilt/Dreamstime.com

These wind tunnels are used for testing at NASA's Ames Research Center near San Francisco, CA, which has long had a reputation for innovation and creative problem-solving. These qualities are urgently needed to tackle the threats that rising sea levels, storm surges, and extreme rainfall pose to our nation's space program.

> ***According to NASA's planning and development office, rising sea levels are the single largest threat to the Kennedy Space Center's continued operations.***

Johnson Space Center

The Johnson Space Center, on Galveston Bay near Houston, is NASA's facility for human spaceflight operations and astronaut training. It is home to the Apollo Mission Control Center, a National Historic Landmark. It also houses the unique collection of returned extraterrestrial samples, including lunar rocks from the Apollo missions.[183] In 2008, when Hurricane Ike crossed the warm waters of the Gulf of Mexico, the storm grew in size, hitting the Texas coast with a 425-mile-wide swath of high winds for up to nine hours.[184,185,186] At the Space Center, more than 160 buildings sustained damage from Ike, while the homes of 250 employees were completely destroyed.[187,188] Such damage may become more common as the climate changes: as sea surface temperatures warm, there is more energy to drive tropical storm winds.[189]

© Christopher Ebdon

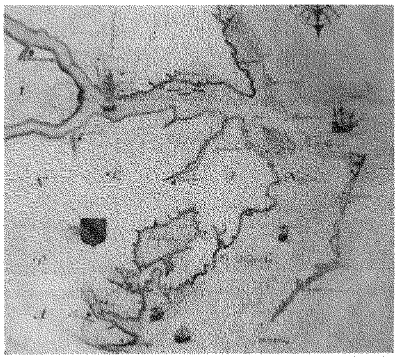
"Okay, Houston, we've had a problem here." In the future, the chilling words of Apollo 13 astronaut John Swigert, Jr. to Mission Control may be used to describe impacts of a new threat to the U.S. space program: as sea surface temperatures warm, there is more energy to drive tropical storm winds.[190] *Above, the right-hand screen shows a space shuttle mission docking with the International Space Station.*

Saving an Icon: Moving the Cape Hatteras Lighthouse Away from the Shifting Shoreline

With its black and white candy-stripe marking, Cape Hatteras Lighthouse on the Outer Banks of North Carolina is one of America's most famous landmarks. More than 200 feet in height, it was the tallest brick building in the world when it was completed in 1870 by the U.S. Army Corps of Engineers.[191] Designed to warn vessels up to 22 miles away of the dangers of nearby Diamond Shoals, in recent years the lighthouse itself was in danger of being lost to the sea.[192]

Coastal erosion and sea level rise prompted the National Park Service (NPS) to take action to save the Cape Hatteras Lighthouse. In 1999, after more than a decade of study and debate, the NPS moved the lighthouse inland.[193] In recent years, sea level has been rising in the Outer Banks two to three times faster than the global average.[194,195] And since 1970, the number of hurricanes in the North Atlantic that reached Categories 4 and 5 in strength has roughly doubled.[196]

As long ago as 1988, a National Research Council study identified increasing rates of sea level rise as one of the factors imperiling the lighthouse.[197] It was 1,500 feet from the ocean when it was built, but by the end of the twentieth century the distance was only 120 feet.[198] The NPS was faced with several options: It could decide not to take any action and let the sea claim the lighthouse, try to protect the structure with seawalls and groins (walls built perpendicular to the shore), or find a way to move it to a safer place. In the end, after much public discussion, the agency decided to shift the whole building.[199]

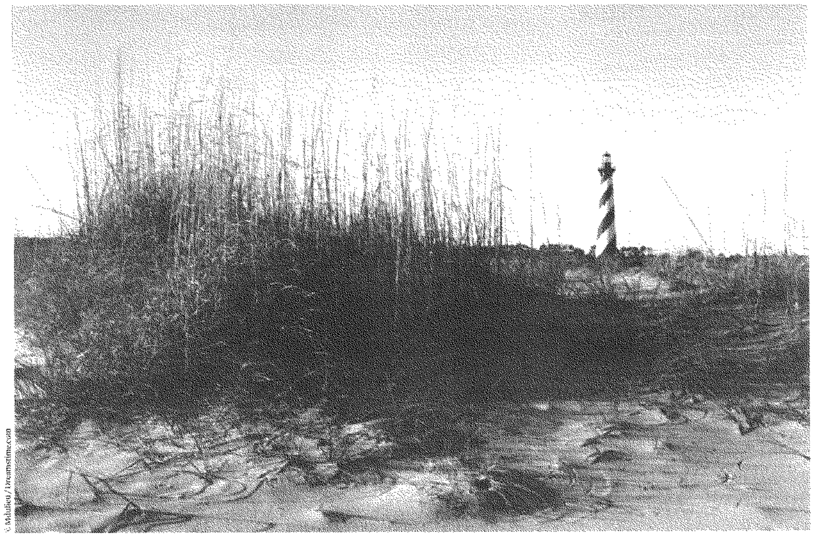


Courtesy of the British Museum

This 1585/1586 map, drawn by John White, illustrates the barrier islands known as the Outer Banks. Here, shifting sands and erosion are natural processes. Over the last three decades, however, sea level has been rising in the Outer Banks two to three times faster than the global average.[201,202]

The lighthouse's original brick and granite foundation was built on a bed of yellow pine timbers that rested on the compacted sand lying just below the island's water table. The construction engineers of the 1860s did not have pile drivers that could penetrate the hard sand, so they devised this elegant solution as an alternative to supporting the tower on deep vertical pilings. As long as the timbers were under fresh water, they would not rot. But erosion of the surrounding sand and the intrusion of saltwater would threaten the foundation and therefore the entire building.[200]

So the Cape Hatteras Lighthouse, weighing over 4,800 tons, was lifted from its foundation using a complex system of jacks and support beams, and slowly and



© Mdalien / Dreamstime.com

The Cape Hatteras Lighthouse, a witness to Spanish and pirate ships, Civil War battleships, and German U-boats, was moved inland nearly 3,000 feet to escape relentless sea level rise and coastal erosion—at a cost of approximately $11 million.[203]

painstakingly moved nearly 3,000 feet to the southwest along an improvised steel track. The keepers' quarters and several other historic buildings were also moved.[204]

The situation at Cape Hatteras is not unique. Along its full length, the Outer Banks system of barrier islands is vulnerable to higher seas and strong storms.[205] Barrier islands are constantly changing; they naturally migrate toward the mainland as storms and waves wash sand over them, replenishing the area behind them. But faster sea level rise accelerates the process, and the increased pace of coastal development has brought more people and infrastructure into harm's way.[206]

More than 3 million visitors come to the Outer Banks each year to visit its landmarks and attractions, such as the Cape Hatteras Lighthouse, the Wright Brothers National Memorial, and the "Lost Colony," the first English attempt to settle what is now the United States, on nearby Roanoke Island.[207] Many families return summer after summer, and tourism is a vital economic engine for the eastern part of North Carolina. Many efforts to reduce vulnerability to coastal erosion and storms have been undertaken along the coast, including nourishment of beaches and the rebuilding of dunes, but storms regularly erase these measures.[208,209,210] Highway 12, the main route along the Outer Banks, and the Bonner Bridge across the Oregon Inlet are part of the vital but vulnerable infrastructure. Hurricane Irene caused two breaches of Highway 12 in 2011; Hurricane Sandy dumped three to four feet of sand on the roadway in 2012; and in 2013 a nor'easter again buried the highway.[211,212,213,214]

The Cape Hatteras Lighthouse continues to attract more than 3 million visitors every year.[215] But as climate-change impacts continue to become manifest, the hard choices that were made in deciding how to respond to an imminent threat to the lighthouse's future will have to be made again and again for other cherished national heritage sites.

Preserving the Past by Planning for Future Floods

Preserving the past is as much a part of the culture of Charleston as the Spanish moss that drapes from its live oak trees and the ample rain that falls on the South Carolina coast throughout the year. Standing in one of Charleston's quaint streets, one can imagine being there in the nineteenth century well before the Civil War.

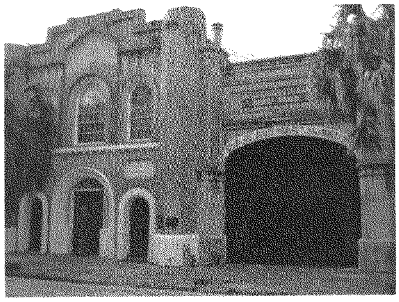
The passion for historic preservation in this colonial-era city took firm hold a century ago, driven by a desire to convey Charleston's role in the development of the nation. Pioneering laws passed in 1931 to protect the city's architectural jewels led to the creation of its Old and Historic District—a national landmark that now includes more than 4,800 historic structures—which became a model for cultural stewardship across the country.[216]

But protecting notable buildings from the wrecking ball or the ravages of time may no longer be enough to save some of Charleston's most treasured resources. The city's longtime struggle with flooding is expected to worsen over the coming decades as global warming continues to increase the pace of sea level rise and causes the heaviest rainfall events to dump more water than in decades past.[217,218]

Established in 1670, Charleston soon became a major port, prosperous trading center, and one of the South's most sophisticated cities. Its architecturally distinct Old Exchange and Provost Dungeon, completed in 1771 as the colony's cultural center, is South Carolina's oldest public building.[219]

Charleston's long military history includes the first naval victory over the British in the War of Independence and the first shots fired by the Confederacy on Union forces at Fort Sumter, thereby sparking the Civil War.[220]

The city is also inextricably tied to the deplorable saga of Southern slavery. The Old Slave Mart Museum, housed in a former slave auction gallery, recalls the harrowing stories of Africans who cultivated plantation crops for long hours under harsh conditions.[221]



© Robin Stevens

As many as 40 percent of enslaved Africans came to the United States through Charleston, many sold at the Old Slave Mart, which is now a museum. Millions of African-Americans today can trace their roots to people who arrived at the Charleston port.[225]

Today, nearly 5 million visitors a year flock to Charleston to savor its Southern hospitality; admire picturesque mansions with high ceilings, ornate plaster, and deep verandas; or tour sprawling eighteenth-century plantations along the nearby Ashley River Road National Scenic Byway.[222]

Charleston also attracts much attention for its modern amenities such as restaurants, galleries, and the annual Spoleto Festival USA, which is internationally recognized as one of the premier performing-arts festivals in the United States.[223] According to the College of Charleston's School of Business, tourism during 2012 pumped more than $3.5 billion into the city's economy.[224]

©Konstantin Lobastov/Dreamstime.com

Sea level around Charleston rose almost twice as fast as the global average during the twentieth century—almost a foot since 1921—and the rate is accelerating.[226,227] *Even today, extreme high tides cause saltwater to back up through the storm drains and spill out onto the roads, snarling traffic and sometimes forcing businesses to close.*[228]

But because Charleston is on a harbor off the Atlantic Ocean, is virtually surrounded by water, and lies only a few feet above mean sea level in many places, the city often struggles with flooding—a problem exacerbated by rising sea levels.[229] During simultaneous high tide and heavy rainfall, the stormwater collection system fills with seawater and leaves little room for storm runoff.[230] Even on sunny days, extreme high tides cause saltwater to back up though the storm drains and spill out onto the roads, snarling traffic and sometimes forcing businesses to close.[231] Expensive efforts to build new pumping stations and tunnels are in the works, but the water could still back up whenever the amount of rainfall exceeds the capacity of the new systems.[232]

With air and ocean temperatures on the rise, scientists project that Charleston's flooding problem will only get worse.[233] Already, an increasing percentage of rain comes from extreme storms, which poses increased risk to infrastructure designed for historic, not current, rain patterns.

Routine summer thunderstorms and high tides regularly flood the popular Historic City Market area, sometimes causing residents and tourists alike to wade through thigh-deep water.[234] The frequency of such "nuisance" flooding is also expected to dramatically increase with rising seas. With a sea level rise of four feet—at the high end of the range of what is likely—the market area will become inundated.[235] A sea level rise of only two feet will inundate historic homes south of Colonial Lake Park.[236]

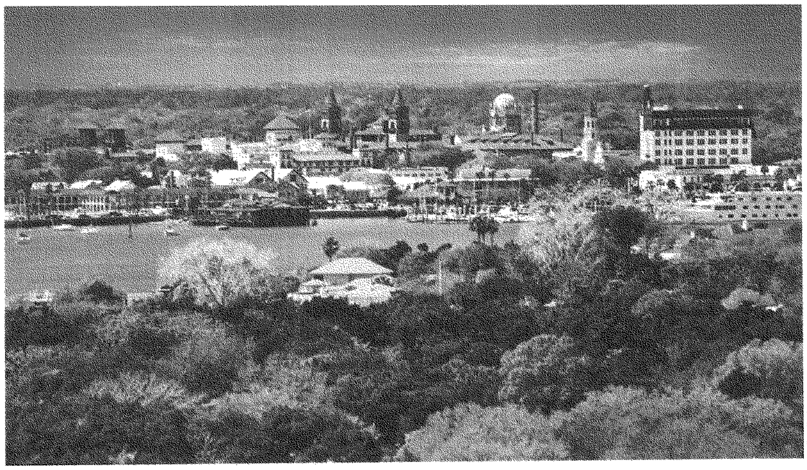
Hurricanes are a major threat to the area during the summer and early fall. And just as warming ocean waters in the North Atlantic can make hurricanes more intense, the seawater is evaporating into warmer air, which holds more water. This can make the heaviest rainfall events even heavier than before.[237] Thus with a changing climate, Charleston residents may face more rainfall in the most intense storms, such as Hurricane Hugo. This Category 4 storm, which struck the South Carolina coast in 1989, killed 26 people, affected 85 percent of the city's properties, and caused more than $6 billion in damage.[238]

Given its growing population and vibrant tourism industry, Charleston will have to be as aggressive in protecting itself from present and future climate change as it has been in preserving the city's cultural past.

Adapting to Climate Change Is Vital to Protecting St. Augustine's Distinctive Heritage

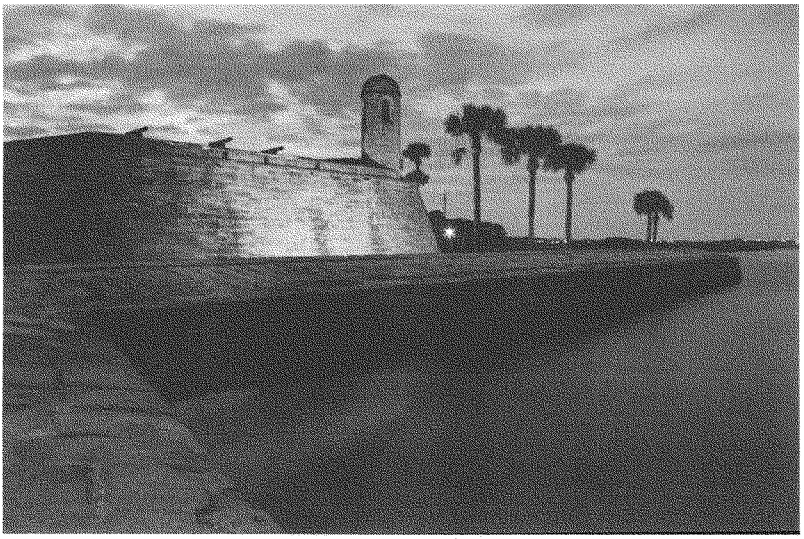
Few cities in the United States boast as many historic distinctions as St. Augustine, FL, but its illustrious past and coastal location come at a price. The low-lying city is prone to flooding, storm surges, and erosion.[239, 239a] And its aging infrastructure takes a beating even in light rainstorms, with nuisance flooding regularly closing streets in the historic districts.[240]

St. Augustine is the oldest city in the nation and home to the first port built in America, the country's earliest Catholic parish,[241] and the oldest masonry fort in the continental United States.[242] Many of the city's buildings are listed on the National Register of Historic Places, with some designated as landmarks worthy of special preservation.



© Mike Baker

Sea level rise, worsening storm surges, erosion, and coastal flooding threaten landmarks in the nation's oldest city.[243] Established in 1565 as a Spanish fort, St. Augustine, FL, was the seat of Spanish rule in North America for 200 years.



© William Trinkle Photography

The Castillo de San Marcos is the oldest masonry fort in North America, and the only seventeenth-century fort that survives today.[244]

The ethnic history of St. Augustine goes back a long way as well. The city holds special meaning for people of Hispanic heritage because it was founded as a Spanish military base in 1565 and was the seat of Spanish rule in North America for the next 200 years.[245] In the late seventeenth century, the government of Spain began granting freedom to people escaping slavery in British colonies to the north, which enabled the first free African-American settlement in North America at Fort Mose, just north of St. Augustine.[246] Following the Civil War, formerly enslaved people settled in what later came to be known as the city's Lincolnville Historic District.[247]

Because sea level rise in response to rising temperatures is worsening coastal flooding, storm surges, and erosion, Lincolnville and most of St. Augustine's other historic districts are now particularly vulnerable, as they generally are at lower elevations than other parts of the city.[248,249] Already, the Atlantic Ocean along Florida's northeastern coast, where St. Augustine is located, has risen by about eight inches since 1930.[250]

Sea level rise could significantly compromise the future of St. Augustine's unique cultural heritage. For example, a rise of three feet, which is well within current projections, could permanently inundate portions of the city's historic

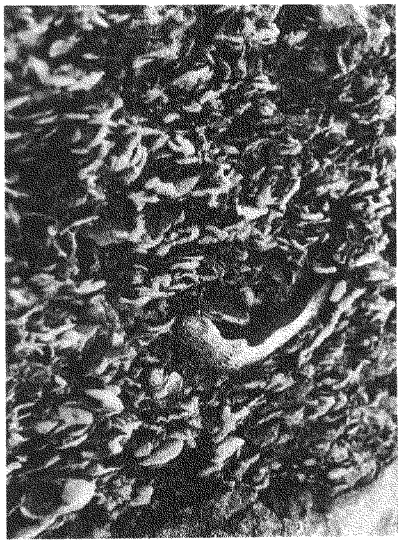
> ***"People in St. Augustine don't realize they are vulnerable. . . . But the increasing pace of sea level rise could overwhelm our ability to stay."***

districts.[251] Meanwhile, storm surges and flooding could undermine the foundations of many historic buildings unless protections are put in place.

Many of the oldest buildings in St. Augustine are constructed with coquina, an early form of concrete made from shells. A prime example of coquina construction is the Castillo de San Marcos, a waterfront fort dating from the seventeenth century, which is now a national monument.[252] Bordering the 20-acre fort is a nineteenth-century coquina seawall that protects the downtown from flooding, but the ocean waves' pounding of the wall during tropical storms has caused its deterioration and created the need for reinforcement.[253] In 2011, the National Park Service built a "living" seawall. Over time, sediment will build up in front of the wall, and marine life and vegetation will establish themselves there, protecting the historic seawall from erosion and creating a natural habitat.[254]

Heritage tourism, attracting more than 5 million visitors a year, contributes substantially to St. Augustine's economic well-being.[255] To boost tourism yet further, work was recently completed on a $16-million project to maintain St. Augustine Beach by adding sand to the eroded shoreline—part of a 50-year commitment by the Army Corps of Engineers to keep it replenished.[256]

Efforts at coastal adaptation in St. Augustine go back centuries to the time of Spanish rule, but rapidly rising sea levels pose new challenges as the city approaches its 450th anniversary in 2015 and faces an uncertain future. It is possible, for example, that at some point in that future (not too many years from now), parts of St. Augustine could no longer be habitable, and this might come as a rude awakening to many of its residents. "People in St. Augustine don't realize they are vulnerable because the government has taken action to keep flooding out," says Kathryn Frank, professor of urban and regional planning at the University of Florida. "But the increasing pace of sea level rise could likely overwhelm our ability to stay there."



©Karen Peterson

This close-up illustrates the coquina construction used at Castillo de San Marcos. The ocean's constant pounding meant the wall required reinforcement, and the National Park Service has taken steps to create a living seawall to protect the historic coquina wall.[257]

A Race against Time for Florida's Prehistoric Shell Structures

Some of the most remarkable archaeological remains in the world are under severe threat from rising sea levels. The huge prehistoric mounds of oyster and clam shells that dot Florida's Gulf and Atlantic coasts may hold the key to understanding the mysteries of Florida's past—but only if we can protect them from worsening erosion and storm damage.

For 4,000 years, early indigenous Floridians lived among the Ten Thousand Islands, an area of keys and mangroves on the southwestern Gulf Coast, now partly within Everglades National Park. They lived off the rich biological resources in and near these shallow coastal waters, eating a wide variety of foods including meat from turtles, small mammals, and deer,

© Irinsicos

Rising seas and worsening storm surge are endangering the massive prehistoric mounds of oyster shells found in Florida's Ten Thousand Islands (above).[258] *Prior to European contact, early indigenous coastal peoples built entire complexes out of discarded shells, thriving in vibrant and well-organized communities.*[259]

© John Stockton

Seeking to protect these remarkable archaeological remains, the National Park Service and the University of Central Florida partnered to protect Turtle Mound from erosion by creating "living shorelines" of submerged mats of oysters and newly planted spartina grass and mangroves.[260] This photo was taken from the top of Turtle Mound.

> ***Archaeologists are now in a race against time to unlock the secrets of some of the country's earliest inhabitants.***

but getting most of their nutrition from fish and shellfish.[261] Over time, they dumped millions of oyster shells in waste piles called middens, which may also have served as a reservoir of potentially useful materials; these indigenous peoples made tools and other objects including hammers, cutting implements, and vessels from conch and whelk shells.[262]

Prehistoric shell middens are common along the U.S. coastline, but Florida's are unique. The state is one of the only places on Earth where coastal hunter-gatherers built such large and complicated shell structures.[263] The shell works, or shell mound complexes, of the Ten Thousand Islands region boast features such as "finger ridges," "plazas," canals, and "water courts." [264] Just a few meters high and often in direct contact with the water at their bases, they were built over many centuries to serve the needs of a growing and well-organized society.[265]

At Dismal Key, for example, low canals run between the finger ridges radiating out to the edge of the site. These canals may have acted as fish traps, water control structures, or channels for canoes to access the community; water courts could have been used to store or even grow fish or shellfish in some form of aquaculture.[266,267]

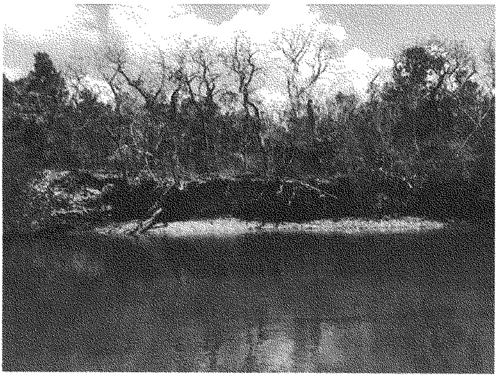
The oldest parts of many of these architectural shell complexes are often large ring-shaped shell structures. Artifacts found on some of these rings, such as drilled sharks' teeth, worked stingray spines, and a limestone pendant suggest they were used for ceremonial purposes or for high-status residences.[268] Clearly these were vibrant and structured communities, and at the time of the first European contact in 1513 there may have been tens of thousands of indigenous Calusa, Timucuan, and other tribes in Florida. But by the mid-1700s they had all but disappeared, victims of disease, warfare, and the slave trade.[269]

Across the Florida peninsula, on the Atlantic coast, lies another massive shell mound. At more than 35 feet tall and covering two acres, Turtle Mound in the northern part of Canaveral National Seashore is thought to be the highest in North America.[270] The mound dates back at least 1,200 years and is such a remarkable feature of this low-lying coast that it was shown as a navigational aid on the first Spanish maps of the region.[271]

Erosion has recently become a major problem for Turtle Mound. Sea level rise, combined with storm surges and boat wakes, has had particularly severe impacts on the mound. Fears that this archaeological treasure could be irreparably damaged have recently prompted the National Park Service to join with scientists at the University of Central Florida in a project to protect Turtle Mound from erosion. Toward that end, they are creating "living shorelines" consisting of submerged mats of oysters, newly planted spartina grass, and mangroves.[272]

Florida has recorded a sea level rise of eight to nine inches in the last 100 years, and state authorities are projecting an accelerated rise of another 9 to 24 inches by 2060.[273,274] In the Everglades, this phenomenon is *already* causing problems. Erosion and storm damage, exacerbated by sea level rise, have collapsed the banks of tidal creeks at Sandfly Key, threatening the important shell-work structures there.[275]

The accelerating rate of sea level rise, combined with extreme rainfall events (which are predicted to increase)[276,277] and their accompanying storm surges, will pose a growing threat to Florida's extraordinary prehistoric shell mound complexes in the coming decades. Archaeologists are now in a race against time to unlock the secrets of some of the country's earliest inhabitants.



© University of South Florida Alliance for Integrated Spatial Technologies

Sea level rise of eight to nine inches in the last 100 years is already causing problems at Sandfly Key in the Everglades.[278] Erosion, pictured above, threatens shell-work structures there.

Mesa Verde's Ancient Artifacts and Dwellings Are Increasingly Exposed to Wildfires and Flooding

Before Mesa Verde National Park was created in 1906, preservationists feared that this rich collection of artifacts and ancient ruins of the Pueblo people's ancestors would fall prey to vandals or thieves—though they did not foresee the impacts of worsening fires.[279] Now, a century later, protecting these ancient ruins means adapting to the hot, dry, and fiery impacts of a changing climate.

The once-nomadic Ancestral Puebloans began settling in the southwest corner of Colorado in the sixth century, a thousand years before Europeans began exploring North America. They built their homes on the high limestone and sandstone plateau of Mesa Verde. By the late eleventh century, they began moving into the sheltered alcoves of the canyon walls beneath overhanging cliffs. They lived in those cliff dwellings less than 100 years before suddenly migrating south into present-day Arizona and New Mexico.[280]

We may never know for sure why its inhabitants abandoned Mesa Verde; archaeologists' theories include depleted resources, crop failures due to drought, and social strife—or some combination of all three.[281] But the handicrafts, mesa-top pueblos, and multi-storied cliff dwellings they left behind give us insights into the lives of these ancient people—the descendants of hunters and gatherers who roamed the plains as long as 10,000 years ago.[282]

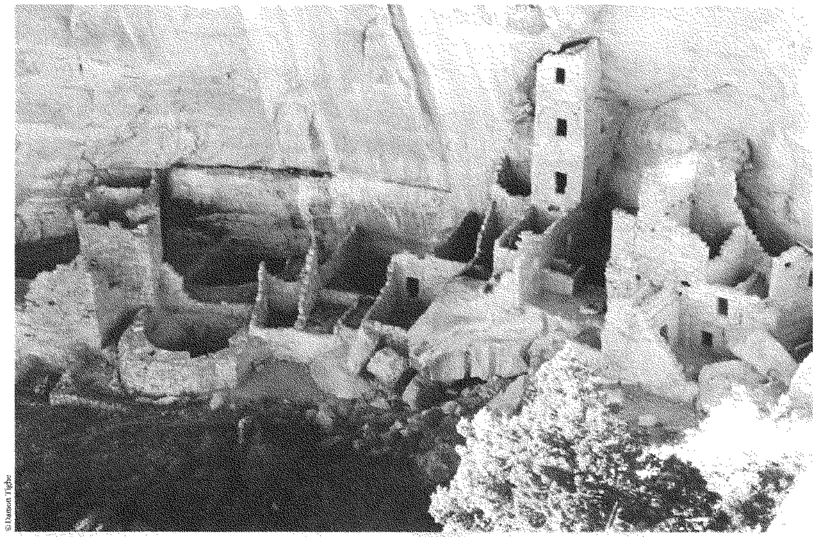
Mesa Verde's remarkably well-preserved Native American treasures, representing the cultural heritage of many of today's tribes—including the Hopi, Zuni, and Laguna—make up the largest archaeological preserve in the United States.[283] Protected until now by its designation as both a national park and a World Heritage Site, it is at risk from global warming.[284]

For the past 50 years, the temperatures in the Mesa Verde area have been rising, particularly during the summer, at a much faster rate than they did over the preceding century.[285] In the Southwest overall, it has been warmer since 1950 than any period of comparable length in at least 600 years.[286]

> **[*Mesa Verde's treasures—more than 4,500 archaeological sites, including 600 cliff dwellings—are worth protecting from the fiery ravages of a hotter, drier climate.*]**

Rising temperatures add to the region's natural wildfire risk and increase the likelihood that when fires do occur they will be larger and even more devastating.[287] Because forests across the western mountains are drier more often and for longer periods, more wildfires are ignited and they spread more easily.[288] Also, winter snowpack is tending to melt almost four weeks earlier than in previous decades.[289] As a consequence, the average number of large wildfires of more than 1,000 acres across the western United States has increased from 140 per year in the 1980s to 250 per year between 2000 and 2012.[290] In the Southwest, the area burned in recent decades increased more than 300 percent relative to the 1970s and early 1980s.[291]

Back-to-back fires in the summer of 2000 burned nearly half of Mesa Verde National Park's 52,000 acres. The Bircher Fire forced the evacuation of some 1,000 visitors because of



© Damon Tighe

Designated as both a national park and a World Heritage Site, Mesa Verde represents the cultural heritage of many of today's tribes—including the Hopi, Zuni, and Laguna. The Square Tower House, above, is just one of the intact cliff dwellings in the largest archaeological preserve in the United States.[292]

the rapid spread of the flames toward the park entrance. The fire closed the park for two weeks, but the day it reopened the park had to be evacuated again when the Pony Fire erupted. Both fires caused extensive damage to park infrastructure—including roadway systems, visitor facilities, and watersheds—but spared the famous cliff dwellings.[293]

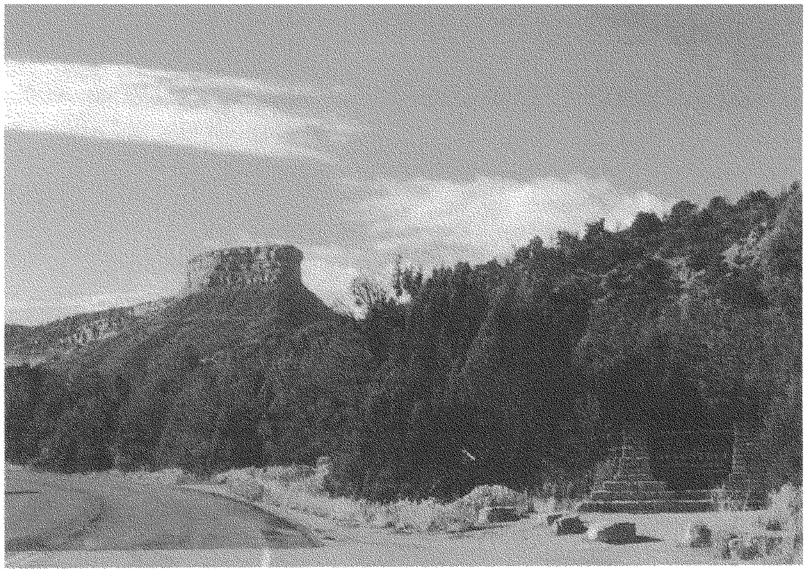
Firefighters work alongside archaeologists to minimize damage to the ancestral ruins, but some harm is inevitable. Because of Mesa Verde's difficult terrain, fire crews use aerial water drops and fire retardant, called slurry, which stains and damages the sandstone. Red stains are now particularly noticeable along the trail to Spruce Tree House, the third-largest cliff dwelling, which contains 130 rooms and eight kivas (communal spaces once used for spiritual ceremonies). Fire also accelerates spalling, the peeling away of the rock face as the water in the sandstone evaporates, which can destroy ancient rock carvings. For example, a major fire in 1996 destroyed a significant petroglyph.[294]

The most devastating impact of a fire, however, can occur after the flames are extinguished, as it also makes the severely burned landscape susceptible to floods and erosion during winter rains. The reason is that fire turns a healthy soil, which normally allows water to seep in, into a hydrophobic (water-repellent) soil, causing rain to run off the surface and erode structures.[295]

"A fire just brings debris down that can silt in sites or it can undermine walls in the alcove sites and the cliff dwellings," Mesa Verde archaeologist Jane Anderson said after the 2000 fires. "It can change the pattern of the runoff so that the water might cling to the walls of the alcoves, run into the backside of the alcove, stain the walls, and undermine architecture that's in there. There's no vegetation above the alcove site to prevent that water from coming in."

Efforts to protect Mesa Verde from flood damage include reseeding with native grasses to promote vegetation growth, placement of erosion-control features such as log diverters to direct water away from sites, and the application of silicone to the cliff faces to redirect natural drip lines.[297]

Currently, a severe drought is plaguing the Southwest, and climate projections suggest more frequent and severe



© Adam Prince

Rising temperatures at Mesa Verde add to the inherent wildfire risk in the region's piñon-juniper forests. Back-to-back fires in the summer of 2000 closed the park, forced the evacuation of roughly 1,000 visitors, and caused extensive damage to the roadways and visitor facilities—but the famous cliff dwellings were spared.[298]

periods of drought in the region during the coming decades as a result of rising temperatures.[299,300,301] Compared with the averages for the twentieth century, precipitation was 4 percent lower, temperatures were 1.3°F higher, and stream flow—the most consistent indicator of drought—declined 16 percent over the first decade of the 2000s.[302]

The high temperatures and dryness of the Colorado Plateau are already having dramatic effects on piñon-juniper forests—the region's dominant wooded ecosystem—which burn easily under these conditions. Sustained heat and drought are weakening piñon pines so much that a combination of drought and bark beetle infestation has caused widespread forest die-off.[303] In 2002 and 2003 alone, heat, drought, and beetles killed 90 percent of the piñon pines in portions of Mesa Verde.[304] This region has lost trees before, but researchers say that more trees died in the recent drought than during previous dry periods because of the higher temperatures caused by climate change.[305]

The vulnerability of Mesa Verde National Park to climate change could have a harmful effect on the region's tourism economy: deterring visitors. In the past, the park has attracted up to a half-million tourists each year, who contribute some $47 million to the local economy.[306] As the first national park designed, in President Theodore Roosevelt's words, to "preserve the works of man," Mesa Verde is home to more than 4,500 archaeological sites, including the 600 cliff dwellings.[307] These cultural artifacts demonstrate the skills of the Ancestral Puebloans at building, making crafts, living off a difficult land, and protecting themselves from the elements by seeking shelter in canyon walls. They are treasures worth protecting.

Pueblos Ancient and Modern Face Increased Risks from Fires and Floods

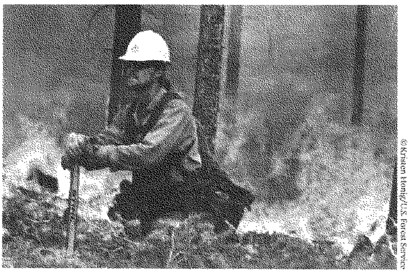
The ancient rock carvings and cliff dwellings of New Mexico's Bandelier National Monument and nearby Santa Clara Pueblo tell the story of some of the earliest inhabitants of the Americas. This landscape of dramatic mesas and beautiful canyons offers evidence of a human presence dating back more than 10,000 years while also serving as home to modern pueblo communities with an enduring sense of cultural identity.[308]

But protecting this Native American homeland is increasingly difficult as the region experiences a long-term warming trend and as large wildfires and extreme flooding events become more common.

The Southwest has been getting warmer—the period since 1950 has been the warmest time interval of comparable length in at least 600 years—and this trend is increasing the risk of more frequent and larger fires.[309] There has indeed been a dramatic rise in the number of large wildfires since the early 1980s, and research suggests that an increase in average annual temperature of just 1.8°F—only slightly more than the area has warmed in the last century—could multiply the incidence of wildfires in New Mexico by four.[310,311]

In recent years there have been several major wildfires in and around Bandelier National Monument. In 2000, the Cerro Grande fire raged through the area, destroying 200 buildings in the town of Los Alamos, including several historic structures from the Manhattan Project era.[312] A survey of the fire's impacts on 470 archaeological sites within the boundaries of Los Alamos National Laboratory found that more than 70 percent of these sites had been damaged, including ancestral Pueblo structures and wooden homestead buildings.[313]

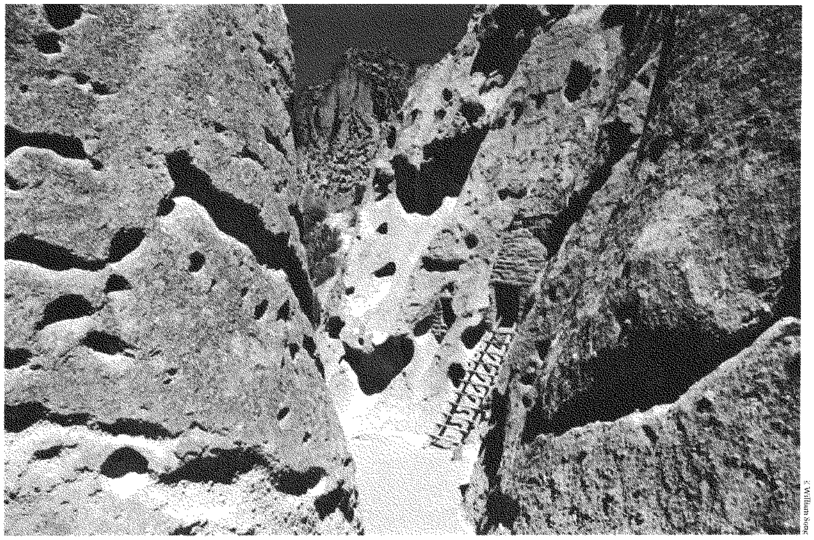
In 2011, the Las Conchas Fire, the second-largest wildfire in New Mexico history, burned more than 156,000 acres, including much forest in Bandelier National Monument and more than 16,000 forested acres belonging to the Santa Clara Pueblo.[314] Not long after the fire, disaster struck northern New Mexico again when heavy rains in the Jemez Mountains surged through the scorched canyons. Santa Clara Pueblo, particularly vulnerable to flooding because of its location at the entrance to the Santa Clara Canyon, was under a state of emergency after heavy rains sent tree trunks, boulders, and other debris rushing down the canyons, toppling power lines and washing out roads and bridges.[315]



© Kristen Honig/U.S. Forest Service

Firefighters battled to protect Bandelier from the massive 2011 Las Conchas Fire. The intense heat from fires can cause flaking on ancient rock carvings, ruin pottery shards and ceramic glazes, and change the chemical composition of soil layers (rendering archaeological dating techniques less accurate).[316]

"This is our only homeland; it's the place we've been entrusted with since time immemorial. But never again in our lifetime will we see our traditional and treasured homeland and spiritual sanctuary, the canyon, as we have known it," said



© William Song

Several large wildfires that raged across northern New Mexico in recent years have left Bandelier National Monument vulnerable. In the fires' wake, heavy rains can cause destructive flash floods, making erosion and extreme rainfall a major threat to the monument's archaeological resources, such as the Talus houses shown above.[317]

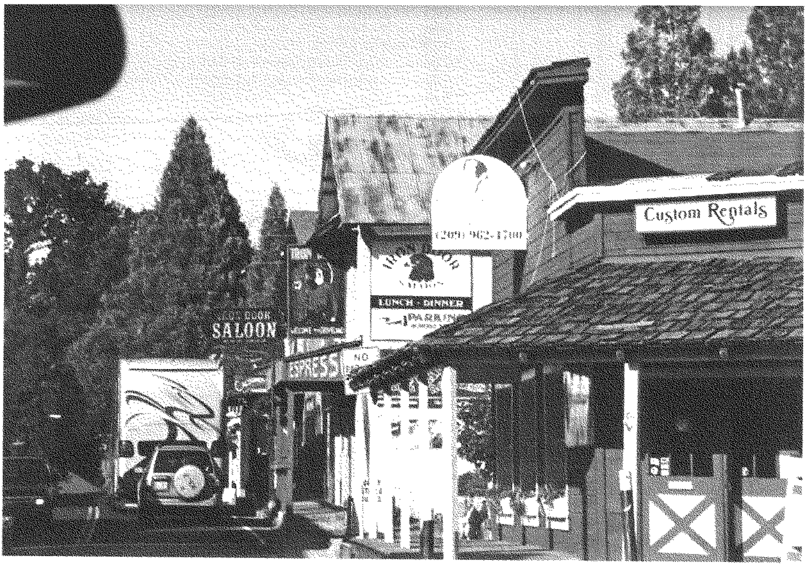
Walter Dasheno, then governor of the Santa Clara Pueblo, at a U.S. Senate hearing. "It will take generations for our community and lands to recover from the devastation of the fire, and because of climate change it is not clear what the future will look like."[318]

Severe flooding from summer thunderstorms also damaged resources at Bandelier National Monument in 2011 and 2012, washing out its popular Falls Trail and Frijoles Canyon Trail,[319] and again in 2013, when the monument experienced the worst flash flooding in its history.[320] Erosion from floods and extreme rainfall is now a major threat to the monument's archaeological resources.

In the aftermath of large wildfires, heavy southwestern summer rains can cause destructive flash floods. Fires have already denuded landscapes of trees, which might check the water, and the scorched soils, transformed so that they temporarily repel (rather than absorb) water, increase surface runoff for months to several years after the fire.[321] Where trees have died back, whether due to drought, wildfires, or other climate-related impacts (such as beetle attacks on piñon pine forests),[322] the risk is even greater. Extreme precipitation events are expected to worsen throughout the region, even where total annual rainfall decreases.[323]

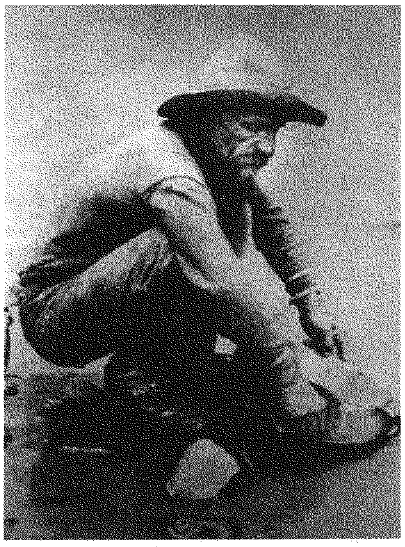
[GROVELAND, CA]

Groveland and Other California Gold Rush–Era Towns Are Imperiled by Wildfires



© K45025|Dreamstime.com

The town of Groveland, a California Historic Landmark, recalls the days of the Wild West, when stagecoaches rumbled past its adobe and wood-framed buildings and conflicts often ended in gunfights. Today, however, the town is dependent on the tourist trade of the 4 million annual visitors to nearby Yosemite National Park.[324]



©L. C. McClure

Contrary to the glamorous, strike-it-rich-quick popular image, gold miners lived in camps under harsh conditions, often succumbing to poor nutrition and disease. Stealing and gambling were rampant in the lawless frontier.

The Groveland Hotel was built as a trading post in 1849 a year after gold was discovered in California's adjacent Sierra foothills, sparking the largest gold rush in American history.[325] The hotel, still operating, is now usually filled with tourists visiting nearby Yosemite National Park, but in 2013 fire officials and television crews occupied it instead. They were there to battle and broadcast the Rim Fire, a blaze that burned more than 402 square miles of the Central Sierra Mountains—an area more than eight times the size of San Francisco.[326]

> **[*Visitors spend $200 million annually in Tuolumne County. But the increasing risk of wildfires threatens both the county's gold rush heritage and its current economy.*]**

California is experiencing a marked increase in giant wildfires.[327] The number of large wildfires now burning each year is double that typical in the 1970s. And of the state's 20 largest wildfires since 1932, 12 have occurred since 2002.[328] The main reason for this growing wildfire risk, not only in California but also across the western United States, is climate change, which drives up temperatures that among other things cause earlier melting of the winter snowpack.[329] As a result, less water is available during the hotter months, forests are drier for longer periods, and they become highly combustible.[330] Average wildfire seasons, which were five months long in the 1970s, now last more than seven months.[331]

The human and economic impacts of these wildfires can be severe. The rapidly growing Rim Fire, for example, overwhelmed the tight-knit Groveland community as some residents lost homes, and businesses were forced to close during the height of the tourist season.[332] The blaze burned for more than two months, smothering Groveland with smoke and closing its Main Street—the most direct and scenic all-weather route to Yosemite for many of the park's annual 4 million visitors.[333,334]

"We only have four to five months of business a year, basically Memorial Day to Labor Day, and to lose this end of August and Labor Day weekend is just financially devastating for the businesses here in town," Corinna Loh, whose family owns Groveland's Iron Door Saloon and was forced to cut staff, told National Public Radio. Loh lost two homes to the Rim Fire and said the blaze spread faster than any she had ever seen since moving to Groveland as a young child.[335] Mark Morales, a retired fire captain, agreed: "I cannot recall any wildfire in recent history that grew this large as quickly. At the present rate of growth this will challenge record acreage for California fires."[336]

The Rim Fire, which spread fast because of parched vegetation and inaccessible terrain, was the third-largest wildfire in California history, and it cost $127 million to fight.[337] Its long duration bears out observations across the West of an abrupt transition in the mid-1980s from a pattern of infrequent wildfires lasting an average of a week to more frequent

© Don Bartletti/Los Angeles Times

In California and other states across the west, average wildfire seasons, which were five months long in the 1970s, are now more than seven months long.[338] *The 2013 Rim Fire (above) spared Groveland's historic landmarks but forced many businesses to close during the height of the tourist season—delivering a devastating economic blow to this small town.*[339,340]

and longer-burning fires.[341] Today, the land around Groveland burned by the fire resembles a moonscape, which raises the risk of flash floods when winter storms hit—the scorched soil makes it more likely that the water will run off, rather than seep into the soil, for months or years after the fire.[342,343]

Extremely dry winter weather, with little precipitation, is putting great pressure on tourism-dependent Tuolumne County, even without fires.[344] Tourism is the county's top private employer, and visitors spend $200 million annually in towns such as Groveland, Jamestown, Chinese Camp, and Columbia, where the State Historic Park brings the Gold Rush back to life with, for example, merchants dressed in 1850s attire and opportunities for visitors to pan for gold.[345,346]

The original miners—called "forty-niners"—found the gold plentiful and easy to extract by panning the gravel of streams and rivers. With pick, shovel, and pan, they dug among the rocks and clay and used water to sift the nuggets from the dirt.[347]

Word quickly spread and people from across America and around the world arrived in what became known as the Mother Lode, hoping to strike it rich. California's population of non-Native American people exploded from 14,000 in 1848 to nearly 100,000 by the end of 1849 and 250,000 by 1852.[348] The Gold Rush helped spur California's admission to the Union as the thirty-first state in 1850. Eureka, a Greek word meaning "I have found it," has appeared on the state seal ever since and likely refers to the discovery of gold.[349]

Wildfires are expected to burn more land, particularly in mid-elevation sites on the west side of the Sierras, making it more likely that Gold Rush–era communities—as well as the majestic Yosemite Valley—will more frequently be in the path of destruction.[350] In order to protect them, preventive efforts have been proposed, including creating buffers free of flammable vegetation around the towns, removing decaying trees from forests, and allowing some fires to burn to eliminate surplus fuel.

[CÉSAR CHÁVEZ NATIONAL MONUMENT]

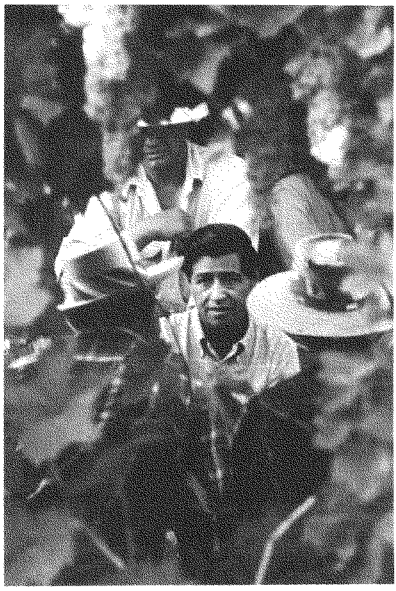
California Farmworkers Championed by César Chávez Are Now Threatened by Extreme Heat and Drought

Before Latino labor leader César Chávez began organizing California farmworkers in the 1960s, migrant grape pickers made as little as a dollar an hour and lived in unheated metal shacks with no indoor plumbing or cooking facilities. Chávez attracted national attention to their plight through fasts, marches, strikes, and a widespread boycott of table grapes. The farmworkers' persistent struggle to improve their lives led to higher wages and safer working conditions.[351,352]

To honor their leader's legacy, President Barack Obama designated the César E. Chávez National Monument on the land where Chávez lived and ran his United Farm Workers (UFW) union in the rural California town of Keene, southeast of Bakersfield. At a dedication ceremony in 2012, Obama praised Chávez for his "belief in the power of opportunity.[353] He believed that when a worker is treated fairly and humanely by [his or her] employer, that adds meaning to the values this country was founded upon."[354]

In the years since Chávez died (in 1993), California farmworkers have been facing new challenges.[355] Extreme heat and drought are endangering the safety and livelihoods of the men and women who harvest nearly half of U.S.-grown fruits, nuts, and vegetables.[356,357,358] The state's unique geography, massive water-resource infrastructure, and Mediterranean climate allowed California to become one of the most productive agricultural regions in the world, but its climate is changing.[359,360]

Scientific research has shown that periods of extreme heat are increasing in frequency and intensity in California, and especially in the San Joaquin Valley—the heart of the state's agricultural enterprise—where average summertime temperatures have been rapidly rising in recent decades.[361,362]



© Arthur Schatz/Time & Life Pictures/Getty Images

César Chávez talking in a field with grape pickers in support of the United Farm Workers Union, Delano, CA, March 1968.

© Sam Garcia/The City Project

The national monument celebrating the accomplishments of farmworker leader César Chávez and the movement he headed is one of the nation's most recent heritage sites. Shown at the groundbreaking for the historic park—comprised of five sites in California and Arizona—is former Secretary of the Interior Ken Salazar and National Park Service Director Jon Jarvis.

Hot days are becoming more common, and it is no longer cooling off as much at night. Such changes, which began in the 1980s, appear to have accelerated since 2000.[363]

Climate models show that if our emissions of carbon dioxide and other heat-trapping gases remain high, Bakersfield could have almost 50 days of extreme heat, with temperatures reaching 104°F or more, by 2050—up from four days a year on average between 1961 and 1990.[364]

Extreme heat is already making the lives of California farmworkers harder and more dangerous, leading to increased hospitalizations and deaths.[365,366] Now it appears that such risks are only going to grow for these workers.

California passed the most stringent heat-safety regulations in the nation in 2005, requiring farmers to provide their employees with adequate water, shade, and rest breaks.[367] However, with field worker deaths continuing in the succeeding years, the UFW claimed the laws are often violated and the state does not provide adequate enforcement.[368]

In one particularly tragic case that raised questions about the effectiveness of the laws, Maria Isabel Vasquez Jimenez, 17 years old and two months pregnant, died from heat exhaustion she suffered while working in a grape vineyard near Stockton on a blisteringly hot day in 2008. By the time she was taken to the hospital, Jimenez's body temperature topped 108 degrees. Her coworkers reported to state officials that the nearest water cooler was a 10-minute walk away, and they were not allowed long enough breaks to get a drink.[369,370]

High summer temperatures in California also threaten the health of the agricultural industry itself. And when drought conditions prevail, crop yields may fall and quality may be compromised even further.[371,372]

Recent data indicate that prolonged periods of drought in California—expected with climate change—are on the rise. Californians have spent nearly half of the years since 2000 in dry and critically dry conditions, a marked increase over the previous century.[373]

The state is now in one of its worst droughts since record keeping began, as 2013 had the least amount of rainfall on record. In March 2014, more than 90 percent of California was suffering from at least a "severe drought," 72 percent was experiencing at least an "extreme drought" and 22 percent—including a wide swath of the San Joaquin Valley—was in an "exceptional drought," according to the U.S. Drought Monitor.[374]

Prolonged drought threatens to cripple California's agricultural industry, which currently uses 80 percent of the state's available water resources.[375] In early 2014, federal and state officials notified some farmers that they would not receive any deliveries of irrigation water.[376,377] As a consequence, some farmers may be forced to leave their fields fallow.[378] That could mean thousands of lost jobs for seasonal farmworkers and higher prices and fewer choices for consumers.

A drought in 2009 caused $340 million in revenue losses in the San Joaquin Valley, when 285,000 acres were left idle and nearly 10,000 jobs were lost.[379] This year, the situation could be even worse. Farm organizations are projecting that up to 800,000 acres of the California farm belt will remain unplanted in 2014, with crops such as tomatoes, broccoli, lettuce, melons, and corn particularly hard hit.[380]

"We're in a dire situation that we've never been in before," said Paul Wenger, president of the California Farm Bureau Federation.[381]

In early 2014, normally the height of the rainy season, the fields were parched around the Chávez National Monument, located at the southern end of California's 450-mile-long Central Valley—the state's top-producing agricultural region.[382] While it is often called "the nation's salad bowl" for the array of fruits and vegetables grown in its fertile soil, this region also is home to some of California's most disadvantaged communities, and poor air quality is a persistent problem.[383,384,385]

The monument was created on a property known as Nuestra Señora Reina de la Paz, which includes the UFW headquarters and the Chávez family home—already on the National Register of Historic Places.[386] It was here that César Chávez advocated for the passage of California's Agricultural Labor Relations Act of 1975, the first law in the nation to recognize farmworkers' collective bargaining rights.[387] The union he helped create—the country's first permanent agricultural union—grew into a national voice for the poor and disenfranchised.

To create greater public awareness of Chávez's achievements, the National Park Service (NPS) announced plans in

Periods of extreme heat are increasing in frequency and intensity in California, and prolonged periods of drought—expected in the state as the climate changes—are on the rise.[388] Hotter conditions are the newest threats to the health and safety of farmworkers who harvest most of the country's vegetables and fruits—seen here cutting and packing celery in Salinas, CA.[389]

October 2013 for a César Chávez National Historic Park, which would contain five sites in California and Arizona (including the national monument) relevant to the leader's life.[390] The proposed park, which must be approved by Congress, is part of an effort by the NPS to tell a more inclusive story of America's heritage.

Yet another way to pay tribute to Chávez would be to protect from environmental harm the farmworkers he championed and the agricultural industry on which they depend. Mechanisms for adapting to a hotter and more drought-prone environment with improved worker protection and water management measures, and policies for reducing the emissions driving these climate impacts, are urgently needed.

> ***Extreme heat and drought are endangering the safety and livelihoods of the men and women who harvest nearly half of U.S.-grown fruits, nuts, and vegetables.***

[BERING LAND BRIDGE NATIONAL MONUMENT & SHISHMAREF, CAPE KRUSENSTERN NATIONAL MONUMENT & KIVALINA]

Native Villages and Ancestral Lands in Alaska Face Rapid Coastal Erosion

Arctic warming is reducing winter ice in the Chukchi Sea, causing the thawing of permafrost (subsoil that remains frozen year-round) and threatening not only native Alaskan communities—many of which go back thousands of years—but also some of the oldest archaeological sites in the western hemisphere.[391,392]

© Sam Garcia/The City Project

The first humans to populate North America may have arrived as long as 15,000 years ago across the Bering Land Bridge from Siberia.[393] *Artifacts from as long as 4,000 years ago are at risk in coastal archaeological sites in the Cape Krusenstern National Monument and the Bering Land Bridge National Preserve (above).*[394]

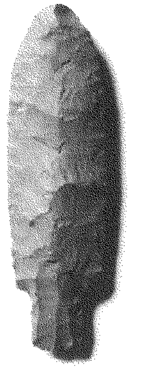
Genetic studies have shown that all Native American groups originated from south Siberia. The first humans to populate North America, they arrived perhaps as much as 15,000 years ago, or even earlier, as the ice of the most recent Ice Age retreated.[395] The ancestors of the indigenous people that now inhabit western Alaska today likely migrated later, arriving around 5,000 years ago.[396] These ancient migrants were mobile subsistence hunter-gatherers, and even now, subsistence hunting and gathering is at the core of a lifestyle connecting Alaskan natives directly to the places where their ancestors lived.[397]

Archaeological remains that help us piece together the story of early Americans are scattered across northwestern Alaska's remote and vast terrain. Some of the densest concentrations of artifacts are found in two national parks that face each other across Kotzebue Sound—the Bering Land Bridge National Preserve and the Cape Krusenstern National Monument—both of which were designated for the importance of the cultural heritage they preserve.[398,399]

Cape Krusenstern protects a series of more than 100 beach ridges, which host archaeological sites that date back 4,200 years and which preserve clues from virtually every phase of Inupiat Eskimo development.[400,401] At the Bering Land Bridge, fluted stone points more than 12,000 years old, some of the earliest human signs in the Americas, have been found inland at Serpentine Hot Springs.[402] But permafrost degradation due to climate change is damaging some important cultural heritage sites, and coastal erosion is washing away irreplaceable archaeological artifacts at particularly vulnerable coastal locations.[403]

Alaska has warmed more than the lower 48 states in recent decades.[404, 405] Average temperatures across the state have increased by about 3°F over the last 60 years, with winter and spring temperatures warming the most.[406] Over the last three decades, sea ice extent in the Arctic summer has declined more than 10 percent every decade, with new record-low levels of ice occurring on a regular basis.[407] Moreover, permafrost is warming and thawing in many parts of the state.[408]

[Climate change is threatening both native Alaskan communities and some of the oldest archaeological sites in the Western Hemisphere.]



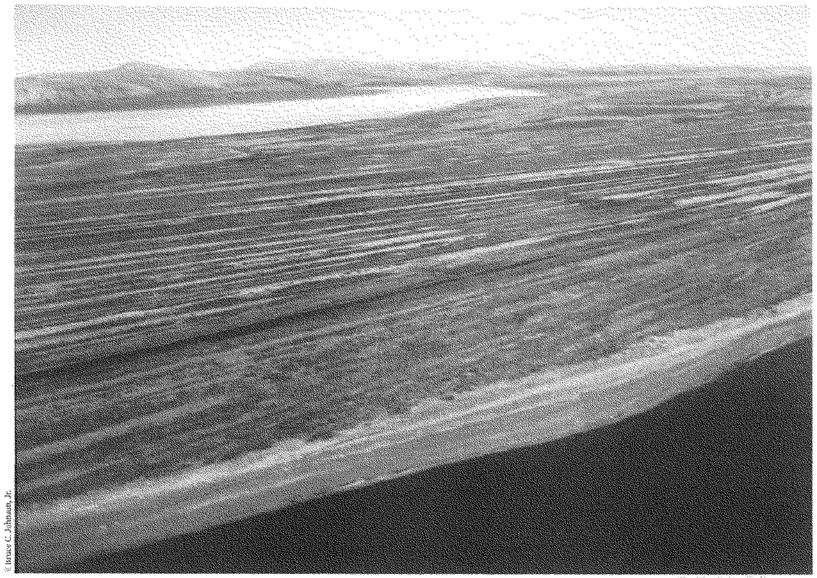
©Shelby Anderson

As Alaska warms (on average by about 3°F over the last 60 years), protective sea ice is lost, permafrost thaws, and coastal erosion increases.[418,419,420,421] *Irreplaceable archaeological artifacts, like this biface spear point from Cape Krusenstern that dates to the Choris period (between 800 and 500 B.C.), are increasingly threatened.*

The combination of the loss of protective seasonal sea ice, the resulting increase in ocean waves near the shore, and the thawing permafrost is leading to severe erosion in coastal areas.[409,410] In the past, sea ice protected the coastline from erosion during winter storms, but a lengthening ice-free season has hindered this shielding process: given that increasing ocean and air temperatures cause winter sea ice in the Chukchi and Bering seas to form later in the year, more storm damage to the coastline results.[411,412] Wave heights during extreme events have also increased over the last 20 years.[413]

The U.S. Government Accountability Office has concluded that out of more than 200 native Alaskan villages, 85 percent are already being affected by erosion and flooding and that 31 are under imminent threat.[414,415] Twelve of these communities have decided to completely relocate.[416]

One such community is Kivalina, a small village just north of Cape Krusenstern. Winter storms are removing an average of up to 35 feet of Kivalina's shoreline annually; however, in 2005, the town lost 70 feet from the beach to a single massive storm.[417] The residents of Kivalina hunt walrus, seal, caribou, and fish, and it is the only village in the region that still hunts



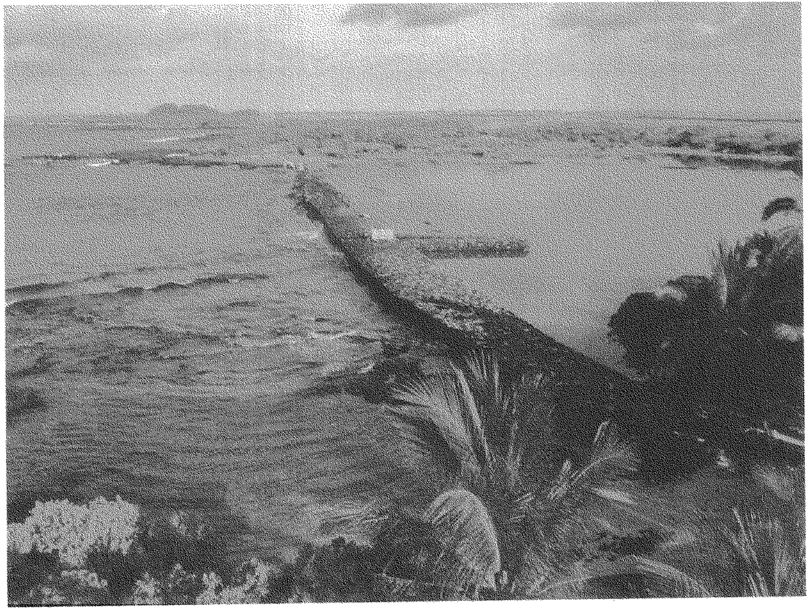
© Bruce C. Johnson, Jr.

Beach ridges at Cape Krusenstern preserve artifacts from the ancestors of today's Inupiat Eskimo people. But climate change is damaging not only invaluable cultural heritage sites but also the Inupiat's current way of life. Twelve native Alaskan communities have decided to completely relocate to escape coastal erosion and flooding.[422]

bowhead whales, at least in principle—no bowheads have been taken in more than a decade, and locals blame the changed ice conditions.[423] Cost estimates for moving the community of Kivalina to a new and safer location are about $100 million.[424]

Across the bay, and adjacent to the Bering Land Bridge National Preserve, another Inupiat village, Shishmaref, is also at risk from the rising temperatures. Tony Weyiouanna, president of the board of the Shishmaref Native Corp., told a congressional task force in January 2014 that, "The shortening winter season is impacting our local subsistence culture and our ability to create jobs and investment for our community. It's attacking us from all sides."[425] Echoing a report from the U.S. Army Corps of Engineers, he told a state working group, "The no-action option for Shishmaref is the annihilation of our community." [426,427]

Sea Level Rise Threatens Hawaiian Cultural Heritage Sites



© National Park Service

The skills associated with building and maintaining fishponds and fish traps, seen here at Kaloko-Honokōhau National Historical Park, were highly developed in Hawaii. The sea around the Big Island is already rising and projected to continue rising—and could increase the risk of damage to the historical parks and their sacred contents.[428]

The west coast of Hawaii's Big Island is rich in cultural and archaeological sites that remain immensely important for Native Hawaiians today. But many of these sites are threatened by coastal flooding linked to rising sea levels.[429] Numerous sacred places and ancient trails, seawalls, and fish traps are vulnerable to wave action and erosion.[430]

For example, important Hawaiian cultural resources at Pu'uhonua o Hōnaunau National Historical Park are at risk.[431] The park lies on the lava flats of the Kona Coast, less than four miles south of Kealakekua Bay, where one of the earliest contacts between Europeans and Native Hawaiians took place and where Captain James Cook was killed in 1779.

A *pu'uhonua* was a wartime place of refuge, where noncombatants and defeated warriors alike could find sanctuary. Hawaiians lived under strict codes and laws, and certain things were sacrosanct. The penalty for breaking *kapu* (sacred laws) would often be death, but the *pu'uhonua* also offered sanctuary to those who had broken sacred laws.[432]

The National Park Service has identified the Great Wall, along with the 'Āle'ale'a Heiau temple site, other structures in the *pu'uhonua*, and two historic sections of trail, as among the park's cultural resources most vulnerable to sea level rise.[433] The 'Āle'ale'a Heiau is a stone platform within the *pu'uhonua* that is thought to have been built as part of the sacred refuge but then became a place where chiefs relaxed and watched hula dancing.[434] These and other irreplaceable cultural resources are located in low-lying areas of the park that have repeatedly been damaged by storm surges and flooding in the past.[435]

The backdrop to Pu'uhonua o Hōnaunau is the Mauna Loa volcano, where the National Oceanic and Atmospheric Administration, together with the Scripps Institution of Oceanography, maintains an observatory that has the world's longest high-quality record of atmospheric CO_2 concentrations.[436] The remote location and clean air make the site ideal for monitoring the state of the atmosphere. The Mauna Loa record—also known as the Keeling curve, after the scientist Charles David Keeling, who began taking the measurements in 1958—is used by climate scientists worldwide. In 2013 the Keeling curve indicated that atmospheric CO_2 concentrations for part of that year topped 400 parts per million—levels that haven't been seen on Earth for more than 3 million years.[437]

Farther north on the Big Island's west coast, at the base of the Hualalai volcano, is Kaloko-Honokōhau National Historical Park, where sea level rise threatens ancient structures that were used for trapping and raising fish.[438] The skills associated with building and maintaining fishponds and fish traps were more developed in Hawaii than in any other part of Polynesia, and the examples at Kaloko-Honokōhau, some of which are being restored for use in present-day traditional aquaculture, are among the most important in the islands.[439]

©Gary and Melissa Amable

The pu'uhonua *in this park is the best-preserved in Hawaii. The refuge is bounded by the ocean on its northern and western sides, but to the east and south it is protected by the Great Wall—a massive structure 12 feet high, 18 feet wide, and close to 1,000 feet long. The wall is more than 400 years old, and one of the masonry techniques used in building its interior section—by laying lava slabs on top of upright stones—has been found nowhere else on the Hawaiian Islands.[448] The National Park Service has identified the Great Wall (above) at Pu'uhonua o Hōnaunau National Historical Park, as well as the temple site and sections of the historic trail, as cultural resources vulnerable to sea level rise; they have been damaged by storm surges and flooding in the past.[449]*

A coastal hazard analysis, carried out for the National Park Service by scientists from Stanford University and the University of Hawaii, identified the Kaloko fishpond, the 'Ai'ōpio fish trap, and the 'Aimakapā fishpond as among the park's historic features most at risk from coastal hazards.[440] The beach in front of the 'Aimakapā fishpond, which was used to raise fish for the royal chiefs and may be more than 600 years old, is currently eroding at a rate of three to four inches per year.[441] Because the beach separates the pond from the ocean, if this rate of change continues, the number of times the beach is overtopped by waves each year will likely increase; the pond could be breached altogether by 2050.[442] Similarly, the walls of the 'Ai'ōpio fish trap could be completely submerged by the end of the century.[443]

Meanwhile, tide gauges show that the sea around the Big Island is already rising and projected to continue rising—the result both of global warming and subsiding land.[444,445,446] Higher sea levels could increase the risk of coastal floods' damage to the national historical parks and their sacred contents, as floodwaters would be higher and able to move farther inland, and would worsen erosion of the sand deposits on which the structures are built. Greater damage could also result from the pounding of storms' high waves, which would ride on higher seas. Moreover, a rising ocean could exacerbate the impacts of periodic extreme events such as tsunamis (caused by earthquakes), storm surges, and typhoons.[447]

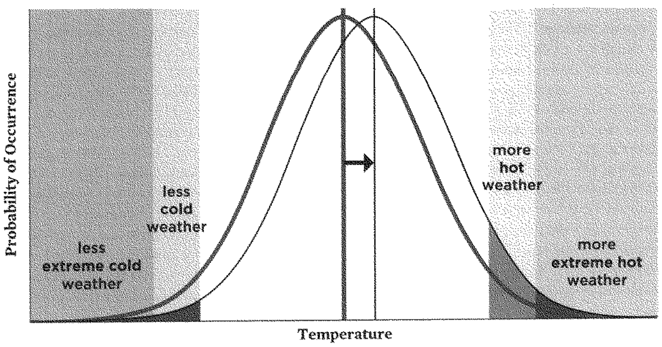
The Science behind the Changing Risks to Our National Treasures

This chapter examines the science on which the growing threats cited in the above stories are based. We discuss the increased chances of extreme weather, rising temperatures, wildfires, coastal flooding, soil erosion, and situations of either too much or too little water.

Shifting Extremes

Earth's global average surface temperature has risen since the late 1800s.[450] Scientists are more certain than ever that since 1950 the warming has been largely due to human activities,

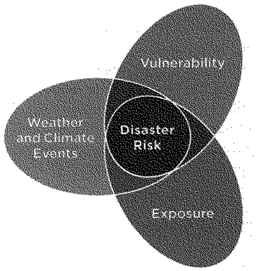
FIGURE 3. Shift in Extreme Events



The figure shows the effects of a simple shift in a region's temperature distribution toward a warmer climate.

ADAPTED FROM IPCC 2012.[451]

FIGURE 4. Factors That Influence Risk Include Exposure, Vulnerability, and Hazards



ADAPTED FROM IPCC 2012.[452]

mostly from the heat-trapping emissions produced by the burning of coal, oil, and gas to provide energy.[453] The global average rate of warming is currently 0.7 degree Fahrenheit (°F) per century.[454] Temperatures in the lower 48 of the United States are rising even faster, at 1.3°F per century.[455] This shift in temperature means that the risk of extreme heat is more likely, and at a level that some places have never before experienced (Figure 3).[456] In other words, the extremes become even more severe, and what used to be extreme becomes commonplace.[457]

Extreme events have the power to transform, sometimes permanently, physical structures, landscapes, and entire ecosystems. And the intensity of such events' effects range from the inconvenient to the deadly. Extreme heat, for example, can mean that outdoor work must be restricted during parts of the day, but in the most severe cases many people may die.[458]

The increased likelihood of extreme events has practical consequences for the sites discussed in this report and the risks they face. Risks change, based on the exposure and vulnerability to hazards, which in turn arise from a combination of natural variability and human-induced climate change (Figure 4). The sites may become at once more exposed and more vulnerable, as a result of choices that have already been made and those yet to be determined. The shifts in extreme events most closely associated with climate change involve high heat, coastal flooding, intense precipitation, and drought.[459]

Coastal Flooding and Erosion

During most of Earth's past, perennial land ice (such as that found in Greenland, Antarctica, and glaciers around the world) did not exist.[460] But perennial land ice has existed for all of human history, and is a key factor in determining sea level. Since the end of the preindustrial period, human-induced climate change has increased temperatures such that nearly all measured glaciers are melting. Shrinking land ice, combined with expanding oceans (as a result of warmer water), increases the rate of sea level rise.[461] Local land subsidence is also a factor. As a result, many coastal areas could progressively become inundated; for example, sea level rise along the U.S. Gulf and East Coasts is among the highest in the world.[462,463] And note that from this point forward, every additional inch of sea level rise is irreversible for at least several human generations.[464]

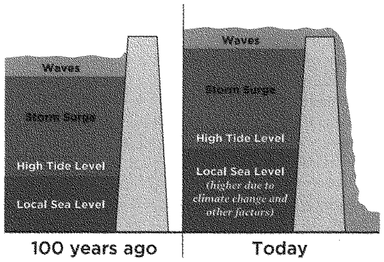
Coastal areas that are not permanently inundated can still experience episodic flooding, resulting from the highest monthly or annual tides, or from strong prevailing winds. Coastal storms can pile water up and create a storm surge capped by waves. Moreover, with each passing decade, these episodic increases in storm surges will occur on top of sea levels that are rising more quickly, primarily because of climate change.[465]

Even if the storm and tidal conditions are entirely of a magnitude that has naturally occurred before, in some cases sea level rise might make all the difference. Consider, for example, a hypothetical storm before industrialization occurred, with the degree of flooding determined by the combined water height of the storm surge, high tide, local sea level, and the effect of wind conditions. In such a storm, the net water level might be just below the height that could overtop the shoreline high point. However, once the climate change–induced increase in local sea level rise is added, that high point could be overtopped (Figure 5, p. 54). Furthermore, when the coastal region is low-sloping, the water can flow inland over great distances.

Coastal erosion can be accelerated as well when storms ride in on ever-higher seas. A severe example of an increase in such erosion is off the coast of Alaska, where the coastline is thick permafrost, comprised of frozen ice and soil. In the past, offshore sea ice prevented winds from making waves during the stormy season. But as climate change melts the offshore sea ice, these coasts are feeling the full brunt of storm waves that in turn rapidly erode the permafrost, which in many places is thawing too.[466]

To assess which possible storm conditions could present a risk to any particular location, scientists and planners look at what is commonly called the 100-year flood. This term

FIGURE 5. Storm Surge on a Higher Sea



A hypothetical worst-case scenario for a storm surge 100 years ago compared with such an event today. Because the rate of sea level rise has increased as a result of human-induced climate change, this boost in elevation combined with naturally occurring factors can spell trouble during a storm surge. The shoreline protections in place, whether natural or engineered, could be overtopped.

means that there is a 1 in 100 chance of such a flood occurring in any given year. Similarly, a five-year flood has a one in five, or 20 percent, chance of occurrence. It is important to remember, however, that this is a probability measure. It does not mean that after a 100-year flood occurs we can expect 99 years until the next one, just as tossing a penny and seeing heads does not affect the likelihood of seeing heads on a subsequent toss.

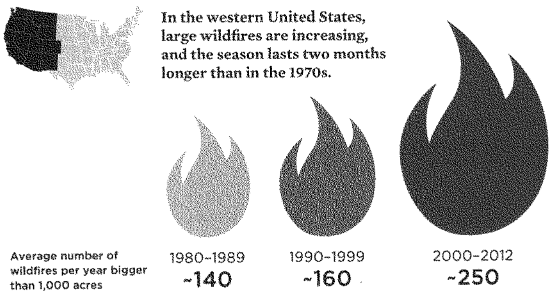
But if another severe flood does happen soon afterward, what constitutes a 100-year flood may need to be reevaluated. With each passing decade, more data are available at each given location, and these data capture the natural and human factors affecting the region. Because scientists have more information to determine the chance of flood heights reaching given elevations, the 100-year flood-level height does tend to change over time. This has already occurred along many parts of the U.S. East Coast, as global sea level rise, together with local factors (such as land-elevation changes and the area's ocean currents), are all taken into account.[467]

Too Little Water or Too Much

Sometimes the water availability in a region departs greatly from the normal conditions that communities expect. Multiple lines of evidence show that climate change is increasing the frequency and severity of some of these extreme departures, regarding cases both of too much and too little water.[468] Too much water over a short period can increase the chances of catastrophic flooding, for example, especially if local infrastructure is designed for a lower sea level or if riverbanks can no longer contain severe flash floods.

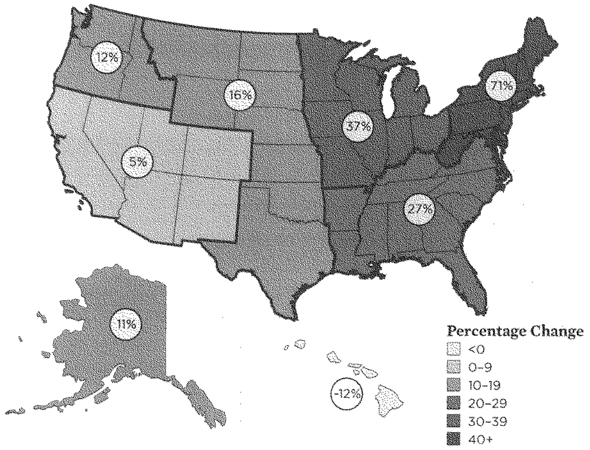
Warmer temperatures increase evaporation rates from surface water bodies. And they also reduce soil moisture, which in turn amplifies the risk of drought.[469] This is especially true for places that already tend to be semi-arid.[470] All else being

FIGURE 6. Changes in Wildfire Size and Season


In the western United States, large wildfires are increasing, and the season lasts two months longer than in the 1970s.

SOURCES: USGS 2013; WESTERLING ET AL. 2006.[471,472]

FIGURE 7. Percentage Change in Very Heavy Precipitation



Percentage change in very heavy precipitation (defined as the heaviest 1 percent of all events) from 1958 to 2012 for each region of the United States. The trend toward more very heavy precipitation for the continental United States, and particularly in the Northeast and Midwest, is clear.[473]

SOURCE: MELILLO ET AL. 2014.

equal, drier and hotter conditions add to the inherent risk of wildfires.[474,475]

In the western United States, climate change has increased temperatures. One study reported that by 2002, snowmelt occurred one to four weeks earlier than it did in 1948.[476] In regions where the earlier snowmelt and runoff are followed by a long, hot, and dry summer, the risks of larger wildfires are elevated.[477] In the western United States, the wildfire season—defined as the period from the first outbreak to the final control date of fires larger than 1,000 acres—has increased more than two months during the period from 1970 to 2012 (Figure 6).[478,479]

Because warmer air can also hold more water vapor, human-induced climate change has raised the overall water vapor content of our atmosphere.[480] When storms occur, more rain or snow may fall compared with similar events decades ago in the same location. Some regions of the United States have shown significant increases in the amount of precipitation falling during the heaviest 1 percent of daily events each year.[481] For example, the Northeast has seen, on average, a 71 percent increase from 1958 to 2012 in the amount falling during the heaviest events; even the arid Southwest registered a 5 percent increase over the same period (Figure 7).[482]

Typically, rain that falls on dry soils seeps in. Once the soil is saturated, additional rain will run off the surface and flow more rapidly downslope, adding to river flood risk.[483,484] But after wildfires, landscapes are denuded, meaning that there remains little vegetation to take up rainwater. Further, the bare ground receives the full impact of rain, thereby further increasing the erosion potential from runoff.[485]

High heat from wildfires can also increase the rate of runoff by altering the soil so that it repels water. A severe wildfire can vaporize the organic material in a soil and change its very chemistry.[486] Gases from the fire penetrate the soil, and when the gases cool they condense to coat the soil with a wax-like substance that repels water. Together, these impacts can cause a soil to become hydrophobic—literally, "afraid of water." This hydrophobia is at its worst immediately after a wildfire,[487] and recovery can take several years. All in all, the likelihood of a flash flood can increase substantially if heavy rains fall on soils altered by wildfires.

Conclusion

The treasured places cited in this report are all subject to increased risks from climate change, such as extreme storms, hotter temperatures, and more frequent and severe floods, droughts, and wildfires. These impacts, of course, are not limited to the cultural and historical resources selected for this report but also are being felt in most cities and towns across the country. Therefore just as the people responsible for maintaining parks, monuments, and landmarks are planning ahead, so can local communities. Reducing carbon pollution by burning fewer fossil fuels will give us more time to prepare and adapt, while possibly preventing the worst aspects of climate change.

© James Jordan

Moving the Cape Hatteras Lighthouse is an example of an action taken to adapt to change, including climate change.[488] *Reducing carbon pollution by burning fewer fossil fuels will give us more time to prepare and adapt, while possibly preventing the worst aspects of climate change.*

[ENDNOTES]

1 *NASA 2011a.*
2 *NPS 2010.*
3 *Gonzalez 2011.*
4 *Caffrey and Beavers 2013.*
5 *Brooks 2012b.*
6 *Hallegatte 2013.*
7 *Brooks 2012a.*
8 *GreatBuildings.com n.d.*
9 *Boston Landmarks Commission 1994.*
10 *Boston Landmarks Commission 1983.*
11 *FEMA 2013.*
12 *NOAA 2013a.*
13 *Boston Harbor Association 2013.*
14 *NPS n.d. (f).*
15 *FEMA 2013.*
16 *Carp 2010.*
17 *City of Boston 2013b.*
18 *Hallegatte 2013.*
19 *Boston Harbor Association 2013.*
20 *Boston Harbor Association 2013.*
21 *NOAA 2014h.*
22 *NOAA 2014h.*
23 *FEMA 2013.*
24 *City of Boston 2013a.*
25 *City of Boston 2013b.*
26 *Cui 2013.*
27 *NPS 2013d.*
28 *Chinese 2013.*
29 *NPS n.d. (u).*
30 *NPS n.d. (i).*
31 *NPS 2013d.*
32 *NPS n.d. (i).*
33 *NPS 2013d.*
34 *NPS 2013d.*
35 *Church and White 2011.*
36 *City of New York 2013.*
37 *NPS 2013d.*
38 *NPS n.d. (i).*
39 *Abreu 2014.*
40 *Harris 2013.*
41 *City of New York 2013.*
42 *NOAA 2013h.*
43 *NOAA 2012.*
44 *Parris et al. 2012.*
45 *City of New York 2013.*
46 *Eissenberg 2013.*
47 *Caffrey and Beavers 2013.*
48 *City of New York 2013.*
49 *NPS 2013d.*
50 *Presidential Proclamation 2013.*
51 *NOAA 2013c.*
52 *Church and White 2011.*
53 *Larsen et al. 2004.*
54 *Larsen 2004.*
55 *Larsen et al. 2004.*
56 *Fritze 2013.*
57 *Boesch 2008.*
58 *NOAA 2013c.*
59 *Boesch et al. 2013.*
60 *Tagger 2013.*
61 *Emanuel 2005.*
62 *Boesch et al. 2013.*
63 *Maryland Department of Natural Resources n.d.*
64 *Kowalski n.d.*
65 *U.S. Fish and Wildlife Service 2009.*
66 *Larsen et al. 2004.*
67 *U.S. Fish and Wildlife Service 2010.*
68 *Larsen et al. 2004.*
69 *Maryland Historical Trust 2013.*
70 *City of Annapolis 2011b.*
71 *Brown 1965.*
72 *U.S. Department of the Interior 1969a.*
73 *U.S. Department of the Interior 1969b.*
74 *NOAA 2013i.*
75 *Sallenger et al. 2012.*
76 *Boesch 2013.*
77 *Hoyos et al. 2010.*
78 *NOAA 2014i.*
79 *Guth 2011.*
80 *Boesch 2013.*
81 *Li et al. 2006.*
82 *NOAA 2013i.*
83 *USACE 2006b.*
84 *USACE 2008.*
85 *Wood 2013.*
86 *NOAA 2013j.*
87 *NOAA 2013i.*
88 *USACE 2006b.*
89 *Maryland Historical Trust 2013.*
90 *NOAA 2013j.*
91 *City of Annapolis 2011a.*
92 *Maryland Historical Trust 2013.*
93 *Maryland Historical Trust 2013.*
94 *NPCA 2007.*
95 *Mitchell 2013.*
96 *Saunders, Easley and Spencer 2010.*
97 *Saunders, Easley and Spencer 2010.*
98 *Holland and Bruyère 2014.*
99 *Grinsted, Moore, and Jevrejeva 2012.*
100 *Eggleston and Pope 2013.*
101 *NPS n.d. (m).*
102 *Cui, Mahoney and Herbowicz 2013.*
103 *NOAA 2014m.*
104 *Church and White 2011.*
105 *Mitchell 2013.*
106 *Mitchell 2013.*
107 *Emanuel 2005.*
108 *Grinsted and Jevrejeva 2012.*
109 *Halainen 2004.*
110 *NPCA 2007.*
111 *Saunders, Easley and Spencer 2010.*
112 *NPCA 2007.*
113 *NPS n.d. (k).*
114 *Goodheart 2011.*
115 *Wilder 1863.*
116 *Hampton University 2014.*
117 *Hampton University 2014.*
118 *Goodheart 2011.*
119 *NPS 1987.*
120 *NPS 1987.*
121 *NOAA 2014m.*
122 *Mitchell 2013.*
123 *Kunkel et al. 2013a.*
124 *NOAA 2014j.*
125 *NPS n.d. (r).*
126 *Rogers 2003.*
127 *USACE 2013.*
128 *U.S. Army 2011.*
129 *Waterway Surveys & Engineering, Ltd., Virginia Institute of Marine Science, and URS Corporation 2011.*
130 *NPS n.d. (r).*
131 *Rogers 2003.*
132 *U.S. GAO 2013.*
133 *NASA 2007.*
134 *NASA 2013d.*
135 *NASA 2013b.*
136 *NASA 2013a.*
137 *Kennedy 1962.*
138 *NASA 2009.*
139 *NASA 2013f.*
140 *NASA 2013g.*
141 *NASA 2014b.*
142 *NASA 2002.*
143 *NASA Jet Propulsion Laboratory n.d.*
144 *Stofan et al. 2007.*
145 *Carr et al. 1998.*
146 *European Space Agency 2000.*
147 *NASA 2012b.*
148 *Boffey 1986.*
149 *NASA n.d. (b).*
150 *NASA 2011b.*
151 *Samenow 2011.*
152 *NASA Goddard Institute for Space Studies 2014.*
153 *NASA 2014a.*
154 *NOAA 2013d.*
155 *NASA 2012a.*
156 *NOAA 2013d.*
157 *Turner 2010.*
158 *NASA Wallops Flight Facility 2012.*
159 *NASA 2013e.*
160 *NASA 2013c.*
161 *NASA Langley Research Center n.d.*
162 *NWS Advanced Hydrologic Prediction Service 2014.*
163 *Roberts 2003.*
164 *NWS Advanced Hydrologic Prediction Service 2014.*
165 *Roberts 2003.*
166 *NASA 2011a.*
167 *NASA 2010.*
168 *NASA 2004b.*
169 *NASA John C. Stennis Space Center 2011.*
170 *NASA Marshall Space Flight Center 2013.*
171 *NOAA 2013b.*
172 *Scharroo, Smith and Lillibridge 2005.*
173 *King et al. 2007.*
174 *Halvorson 2005.*
175 *Magee 2011.*
176 *NOAA 2013b.*
177 *NASA 2004a.*
178 *Chaikin 2009.*
179 *Russo, Fisher, and Winslow 2013.*
180 *Burroughs and Iraci 2010.*
181 *Selverston 2011.*
182 *Burroughs and Iraci 2010.*
183 *Stefanov and Lulla 2012.*
184 *NASA Johnson Space Center 2008.*
185 *Koumoudis 2009.*
186 *Overpeck 2009.*
187 *NASA Johnson Space Center 2008.*
188 *NASA Office of Inspector General 2011.*
189 *Elsner, Kossin, and Jagger 2008.*
190 *Elsner, Kossin, and Jagger 2008.*
191 *USACE 2008b.*
192 *Drye 2014.*
193 *NPS n.d. (q).*
194 *NOAA 2014f.*
195 *Sallenger, Doran, and Howd 2012.*
196 *Webster et al. 2005.*
197 *Committee on Options for Preserving Cape Hatteras Lighthouse 1988.*
198 *NPS n.d. (q).*
199 *NPS n.d. (q).*
200 *NPS n.d. (q).*
201 *NOAA 2014f.*
202 *Sallenger, Doran, and Howd 2012.*
203 *NPS n.d. (q).*
204 *NPS n.d. (q).*
205 *Climate Change Science Program 2009.*
206 *Climate Change Science Program 2009.*
207 *Cui 2013.*
208 *Tabb 2013.*
209 *Perry 2013.*
210 *Coastal Planning & Engineering of North Carolina 2013.*
211 *NCDOT n.d.*
212 *Siceloff 2012.*
213 *Nultemeier 2013.*
214 *American Association of State Highway and Transportation Officials 2013.*
215 *Cui 2013.*
216 *NPS n.d. (h).*
217 *Parris et al. 2012.*
218 *Bender et al. 2010.*
219 *South Carolina Department of Parks, Recreation & Tourism 2013.*
220 *NPS n.d. (l).*
221 *NPCA n.d.*
222 *Office of Tourism Analysis, College of Charleston 2012.*
223 *Spoleto Festival USA 2014.*
224 *Office of Tourism Analysis, College of Charleston 2012.*
225 *International African American Museum n.d.*
226 *NOAA 2013e.*
227 *Church and White 2011.*
228 *Allen et al. 2012.*
229 *NOAA 2013e.*
230 *City of Charleston, Public Service Department n.d.*
231 *Allen et al. 2012.*
232 *City of Charleston, Public Service Department n.d.*
233 *Fung and Wolff 2014.*
234 *City of Charleston 2013a.*
235 *NOAA 2014k.*
236 *NOAA 2014k.*
237 *Knutson et al. 2010.*
238 *South Carolina Department of Natural Resources n.d.*
239 *City of St. Augustine n.d. (a).*
240 *City of St. Augustine n.d. (a).*
241 *Joyner 2009.*
242 *NPS n.d. (a).*
243 *City of St. Augustine n.d. (a).*
244 *NPS n.d. (a).*
245 *Joyner 2009.*
246 *NPS n.d. (a).*
247 *NPS n.d. (t).*
248 *Church and White 2011.*
249 *NOAA 2014k.*
250 *NOAA 2013f.*
251 *NOAA 2014k.*
252 *NPS n.d. (a).*
253 *Edwards 2011.*
254 *Edwards 2011.*
255 *St. Augustine Ponte Vedra & The Beaches, Florida Visitors and Conventions Bureau 2004.*
256 *Korfhage 2012.*
257 *Edwards 2011.*
258 *NPS n.d. (j).*
259 *Schwadron 2009.*
260 *University of Central Florida 2011.*
261 *Florida Division of Historical Resources 1990.*
262 *Schwadron 2009.*
263 *Thompson and Worth 2011.*
264 *Schwadron 2009.*
265 *NOAA 2014k.*
266 *Schwadron 2009.*
267 *The Mound House n.d.*
268 *Schwadron 2009.*
269 *Historical Preservation Society of the Upper Keys n.d.*
270 *Lelis 2008.*
271 *Parker 2008.*
272 *University of Central Florida 2011.*
273 *NOAA 2014g.*
274 *Southeast Florida Regional Climate Change Compact Technical Ad hoc Work Group 2011.*
275 *NPS n.d. (j).*
276 *Kunkel et al. 2013a.*

277 Melillo, Richmond and Yohe 2014.
278 NOAA 2014g.
279 NPS n.d. (p).
280 NPS n.d. (p).
281 NPS n.d. (c).
282 NPS n.d. (d).
283 NPS n.d. (c).
284 Garfin et al. 2013.
285 NOAA 2014b.
286 Hoerling et al. 2013.
287 Melillo, Richmond, and Yohe 2014.
288 Westerling et al. 2006.
289 Stewart, Cayan, and Dettinger 2005.
290 USGS 2013.
291 Fleishman et al. 2013.
292 NPS n.d. (c).
293 NPS 2009.
294 NPS 2007a.
295 Chief, Ferré, and Nijssen 2008.
296 Merrill 2000.
297 NPS n.d. (p).
298 NPS 2009.
299 Hoerling et al. 2013.
300 Sheffield and Wood 2008.
301 Seager et al. 2013.
302 Hoerling et al. 2013.
303 Breshears et al. 2005.
304 Breshears et al. 2005.
305 Breshears et al. 2005.
306 Cook 2013.
307 NPS n.d. (p)
308 NPS n.d. (d).
309 Cayan et al. 2013.
310 Climate Central 2012.
311 EPA n.d.
312 Nisengard et al. 2002.
313 Nisengard et al. 2002.
314 Southwest Fire Consortium n.d.
315 NPS n.d. (n).
316 Oster 2012.
317 Chief, Ferré, and Nijssen 2008.
318 Dasheno 2012.
319 NPS n.d. (d).
320 NWS 2013.
321 Chief, Ferré, and Nijssen 2008.
322 Fleishman et al. 2013.
323 Gershunov et al. 2013.
324 California Governor's Office of Emergency Services 2013.
325 Groveland Hotel 2010.
326 InciWeb 2013.
327 California Department of Forestry and Fire Protection 2010.
328 California Department of Forestry and Fire Protection 2013.
329 Stewart, Cayan, and Dettinger 2005.
330 Stewart, Cayan, and Dettinger 2005.
331 Stewart, Cayan, and Dettinger 2005.
332 California Governor's Office of Emergency Services 2013.
333 InciWeb 2013.
334 California Governor's Office of Emergency Services 2013.
335 National Public Radio 2013.
336 Morales 2013.
337 InciWeb 2013.
338 Stewart, Cayan, and Dettinger 2005.
339 National Public Radio 2013.
340 Dean Runyan Associates, Inc. 2013.
341 Westerling et al. 2006.
342 NPS 2013c.
343 Desilets, Ferré, and Ekwurzel 2008.
344 Valine 2014.
345 Dean Runyan Associates, Inc. 2013.
346 Columbia County Chamber of Commerce 2014.
347 California Department of Parks and Recreation n.d. (b).
348 California Department of Parks and Recreation n.d. (b).
349 California Department of Parks and Recreation n.d. (a).
350 Office of Environmental Health Hazard Assessment 2013.
351 Bardacke 2011.
352 Garcia 2012.
353 The White House Office of the Press Secretary 2012.
354 The White House Office of the Press Secretary 2012.
355 NPS n.d. (g).
356 Gershunov and Guirguis 2012.
357 National Drought Mitigation Center 2014.
358 California Department of Food and Agriculture 2013a.
359 CA Department of Water Resources 2010.
360 Office of Environmental Health Hazard Assessment 2013.
361 Gershunov and Guirguis 2012.
362 NOAA 2014a.
363 Gershunov, Cayan, and Iacobellis 2009.
364 California Climate Action Team 2013.
365 Occupational Safety & Health Administration n.d.
366 Guirguis, Gershunov, Tardy, and Basu 2013.
367 O'Leary 2009.
368 UFW 2012.
369 Khokha 2008.
370 OSHA n.d.
371 California Department of Food and Agriculture 2013b.
372 California Department of Food and Agriculture 2013a.
373 Alvord 2014.
374 National Drought Mitigation Center 2014.
375 NASA 2014c.
376 U.S. Department of Interior 2014.
377 California Department of Water Resources 2014.
378 Gorman 2014.
379 Howitt, MacEwan, and Medellin-Azuara 2011.
380 California Farm Water Coalition 2014.
381 Gorman 2014.
382 NASA 2014c.
383 California Department of Food and Agriculture 2013a.
384 Wozniacka 2012.
385 San Joaquin Valley Air District n.d.
386 NPS 2013b.
387 NPS n.d. (g)
388 Office of Environmental Health Hazard Assessment 2013.
389 Gershunov and Guirguis 2012.
390 NPS 2013b.
391 Markon, Trainor, and Chapin 2012.
392 Goebel et al. 2008.
393 Reich et al. 2012.
394 Anderson and Freeburg 2013.
395 Goebel et al. 2008.
396 Anderson and Freeburg 2013.
397 Goebel et al. 2008.
398 NPS n.d. (e).
399 NPS 2007.
400 NPS 2007b.
401 Anderson and Freeburg 2013.
402 Goebel et al. 2013.
403 Beavers 2013.
404 Alaska Climate Research Center 2014.
405 NOAA 2014d.
406 Alaska Climate Research Center 2014.
407 NSIDC 2013.
408 Markon et al. 2012.
409 Francis, Panteleev, and Atkinson 2011.
410 Freeburg and Anderson 2012.
411 Shulski and Wendler 2007.
412 Markon et al. 2012.
413 Francis, Panteleev, and Atkinson 2011.
414 U.S. GAO 2003.
415 U.S. GAO 2009.
416 U.S. GAO 2009.
417 Brubaker et al. 2011.
418 Alaska Climate Research Center 2014.
419 NSIDC 2013.
420 Francis, Panteleev, and Atkinson 2011.
421 Freeburg and Anderson 2012.
422 U.S. GAO 2009.
423 Brubaker et al. 2011.
424 USACE 2006a.
425 Weyiouanna 2014.
426 USACE 2006a.
427 Bronen 2013.
428 NOAA 2014l.
429 Vitousek et al. 2010.
430 Vitousek et al. 2010.
431 Asam and Rowan 2012.
432 NPS n.d. (s).
433 Asam and Rowan 2012.
434 NPS n.d. (s).
435 Asam and Rowan 2012.
436 Scripps Institution of Oceanography n.d.
437 Pagani et al. 2010.
438 Vitousek et al. 2010.
439 Bond and Gmirkin 2003.
440 Vitousek et al. 2010.
441 Vitousek et al. 2010.
442 Vitousek et al. 2010.
443 Vitousek et al. 2010.
444 NOAA 2014l.
445 Church and White 2011.
446 Caccamise et al. 2005.
447 Keener et al. 2012.
448 NPS n.d. (s).
449 Asam and Rowan 2012.
450 IPCC 2013.
451 IPCC 2012.
452 IPCC 2012.
453 IPCC 2013.
454 NOAA 2014e.
455 NOAA 2014d.
456 IPCC 2012.
457 IPCC 2012.
458 OSHA n.d.
459 IPCC 2012.
460 Masson-Delmotte et al. 2013.
461 Church and White 2011.
462 Ishi et al. 2006.
463 Miller et al. 2013.
464 Goelzer 2012.
465 Church and White 2011.
466 Markon, Trainor, and Chapin 2012.
467 Parris et al. 2012.
468 IPCC 2012.
469 Karl 2012.
470 Dai 2011.
471 USGS 2013.
472 Westerling et al. 2006.
473 Melillo, Richmond, and Yohe 2014.
474 Westerling et al. 2006.
475 Cayan et al. 2013.
476 Stewart, Cayan, and Dettinger 2005.
477 Westerling et al. 2006.
478 Climate Central 2012.
479 Westerling et al. 2006.
480 Trenberth 2011.
481 Melillo, Richmond, and Yohe 2014.
482 Melillo, Richmond, and Yohe 2014.
483 Chief, Ferré, and Nijssen 2008.
484 Desilets et al. 2008.
485 Shakesby and Doerr 2006.
486 DeBano 2000.
487 Woods, Birkas, and Ahl 2007.
488 NPS n.d. (q).
489 Hallegatte 2013.

[REFERENCES]

Abreu, R. 2014. Personal communication, January 16. Rafael Abreu is director of sales and marketing at Statue Cruises.

Alaska Climate Research Center. 2014. Recent temperatures. Online at *http://climate.gi.alaska.edu/*, accessed on February 2, 2014.

Allen, A., L. Fenstermacher, C. Lindley, W. Sweet, and C. Zervas. 2012. *NOAA's tide gauge network: Tide station operation and sea level analysis*. Silver Spring, MD: National Oceanic and Atmospheric Administration. Online at *www.oco.noaa.gov/resources/Progress_Reports/Allen_TideGauges_FY11_ProgressReport.pdf*, accessed on October 14, 2013.

Alvord, A. 2014. Water woes: Dramatic increase of droughts in California is a bellwether of future climate impacts. *The Equation*, January 22. Online at *http://blog.ucsusa.org/california-drought-increase-and-future-climate-impacts-385*, accessed on March 12, 2014.

American Association of State Highway and Transportation Officials. 2013. North Carolina DOT reopens Bonner Bridge, continues push for replacement. December 20. Online at *www.aashtojournal.org/Pages/122013BonnerBridge.aspx*, accessed on April 6, 2014.

Anderson, B.T., J. Wang, G. Salvucci, S. Gopal, and S. Islam. 2010. Observed trends in summertime precipitation over the southwestern United States. *Journal of Climate* 23:1937–1944.

Anderson, S., and A.K. Freeburg. 2013. High-resolution chronology for the Cape Krusenstern site complex, northwest Alaska. *Arctic Anthropology* 50(1):49–71. Online at *http://aa.uwpress.org/content/50/1/49.refs*, accessed on February 2, 2014.

Archer, R. 2010. *As if an enemy's country: The British occupation of Boston and the origins of revolution*. New York: Oxford University Press.

Asam, S., and E. Rowan. 2012. *Facilities adaptation to climate change impacts in coastal areas: Workshop findings for Pu'uhonua o Hōnaunau National Historical Park*. NPS Sustainable Operations Facilities Management. Workshop held at Pu'uhonua o Hōnaunau National Historical Park, August 21–22, 2012.

Bakken, G.M. 2000. *Law in the western United States*. Norman, OK: University of Oklahoma Press, 209–214.

Bardacke, F. 2011. *Trampling out the vintage: César Chavez and the two souls of the United Farm Workers*. New York: Verso.

Beavers, R. 2013. *NPS cultural resources inventory and vulnerability assessment. Case study: Bering Land Bridge National Preserve, Alaska; and Cape Krusenstern National Monument, Alaska*. Fairbanks, AK: Alaska Climate Research Center. Online at *http://climate.gi.alaska.edu/*, accessed on February 2, 2014.

Bender, M.A., T.R. Knutson, R.E. Tuleya, J.J. Sirutis, G.A. Vecchi, S.T. Garner, and I.M. Held. 2010. Modeled impact of anthropogenic warming on the frequency of intense Atlantic hurricanes. *Science* 327(5964):454–458.

Boesch, D.F., L.P. Atkinson, W.C. Boicourt, J.D. Boon, D.R. Cahoon, R.A. Dalrymple, T. Ezer, B.P. Horton, Z.P. Johnson, R.E. Kopp, M. Li, R.H. Moss, A. Parris, C.K. Sommerfield. 2013. *Updating Maryland's sea-level rise projections*. Special report of the scientific and technical working group of the Maryland Commission on Climate Change. Cambridge, MD: University of Maryland Center for Environmental Science. Online at *http://climatechange.maryland.gov/publications/updating-marylands-sea-level-rise-projections/*, accessed January 15, 2014.

Boesch, D.F. (editor). 2008. *Global warming and the free state: Comprehensive assessment of climate change impacts in Maryland*. Report of the scientific and technical working group of the Maryland Commission on Climate Change. Cambridge, MD: University of Maryland Center for Environmental Science. Online at *http://climatechange.maryland.gov/publications/global-warming-and-the-free-state-report/*, accessed January 15, 2014.

Boffey, P.M. 1986. Commercial launching by NASA ordered shifted to commercial sector. *New York Times*, August 16. Online at *www.nytimes.com/1986/08/16/us/commercial-launching-by-nasa-ordered-shifted-to-private-sector.html*, accessed on February 12, 2014.

Bond, S., and R. Gmirkin. 2003. Restoring a part of Hawaii's past: Kaloko fishpond restoration. *Ecological Restoration* 21(4):285–289.

Boston Harbor Association. 2013. *Preparing for the rising tide*. Online at *www.tbha.org/preparing-rising-tide-report*, accessed on December 12, 2013.

Boston Landmarks Commission. 1994. *Faneuil Hall: Boston Landmarks Commission study report*. Online at *www.cityofboston.gov/landmarks/publications.asp*, accessed on January 21, 2014.

Boston Landmarks Commission. 1983. *Blackstone Block street network: Boston Landmarks Commission study report*. Online at *www.cityofboston.gov/landmarks/publications.asp*, accessed on January 21, 2014.

Breshears, D., N.S. Cobb, P.M. Rich, K.P. Price, C.D. Allen, R.G. Balice, W.H. Romme, J.H. Kastens, M.L. Floyd, J. Belnap, J.J. Anderson, O.B. Myers, and C.W. Meyer. 2005. Regional vegetation die-off in response to global-change-type drought. *Proceedings of the National Academy of Sciences* 102(42):15144–15148.

Bronen, R. 2013. *Climate-induced displacement of Alaska Native communities*. Washington, DC: Brookings Institution. Online at *www.brookings.edu/research/papers/2013/01/30-arctic-alaska-bronen*, accessed on February 2, 2014.

Brooks, R.B. 2012a. Faneuil Hall was built with slave money. History of Massachusetts. Online at *http://historyofmassachusetts.org/faneuil-hall-was-built-with-slave-money/*, accessed on January 19, 2014.

Brooks, R.B. 2012b. History of early Boston. History of Massachusetts. Online at *http://historyofmassachusetts.org/a-brief-history-of-early-boston/*, accessed on January 21, 2014.

Brown, V.W. 1965. Shipping in the Port of Annapolis 1748–1775: Sea power monograph no.1. United States Naval Institute.

Brubaker, M., J. Berner, J. Bell, and J. Warren. 2011. *Climate change in Kivalina, Alaska: Strategies for community health*. Anchorage, AK: Alaska Native Tribal Health Consortium. Online at *www.anthc.org/chs/ces/climate/upload/Climate-Change-in-Kivalina-Alaska-Strategies-for-Community-Health-2.pdf*, accessed on February 23, 2014.

Burroughs, N., and L. Iraci. 2010. *Climate change impacts and adaptation strategies at NASA Ames Research Center: Full report*. NASA Earth Science Division. Online at *http://nex.nasa.gov/nex/static/media/publication/Climate_Change_Impacts_and_Adaptation_Strategies_NASA_Ames.pdf*, accessed on December 8, 2013.

Caccamise, D.J., M.A. Merrifield, M. Bevis, J. Foster, Y.L. Firing, M.S. Schenewerk, F.W. Taylor, and D.A. Thomas. 2005. Sea level rise at Honolulu and Hilo, Hawaii: GPS estimates of differential land motion. *Geophysical Research Letters* 32(3).

Caffrey, M., and R. Beavers. 2013. Planning for the impact of sea-level rise on U.S. National Parks. *Park Science* 30(1):6–13. Online at *www.nature.nps.gov/ParkScience/archive/PDF/Article_PDFs/ParkScience30(1)Summer2013_6-13_CaffreyBeavers_3647.pdf*, accessed on April 18, 2014.

California Climate Action Team. 2013. *Preparing California for extreme heat: Guidance and recommendations*. Developed by the Heat Adaptation Workgroup, a subcommittee of the Public Health Workgroup. Online at *http://www.climatechange.ca.gov/climate_action_team/reports/Preparing_California_for_Extreme_Heat.pdf*, accessed on March 13, 2014.

California Department of Food and Agriculture. 2013a. California agricultural production statistics: 2012. Online at *www.cdfa.ca.gov/Statistics/*, accessed on March 18, 2014.

California Department of Food and Agriculture. 2013b. *Climate change consortium for specialty crops: Impacts and strategies for resilience*. Online at *www.cdfa.ca.gov/environmentalstewardship/pdfs/ccc-report.pdf*, accessed on March 13, 2014.

California Department of Forestry and Fire Protection. 2013. Top 20 largest California wildfires. Online at *www.fire.ca.gov/communications/downloads/fact_sheets/Top20_Acres.pdf*, accessed on February 6, 2014.

California Department of Forestry and Fire Protection. 2010. California's forests and rangelands: 2010 assessment. Online at *http://frap.fire.ca.gov/assessment/2010/document.php*, accessed on February 6, 2014.

California Department of Parks and Recreation. No date (a). California Admission Day: September 9, 1850. Online at *www.parks.ca.gov/?page_id=23856*, accessed on February 6, 2014.

California Department of Parks and Recreation. No date (b). Gold Rush overview. Online at *www.parks.ca.gov/?page_id=1081*, accessed on February 6, 2014.

California Department of Water Resources. 2014. DWR drops state water project allocation to zero, seeks to preserve remaining supplies. Press release, January 31. Online at *www.water.ca.gov/news/newsreleases/2014/013114pressrelease.pdf*, accessed on March 13, 2014.

California Department of Water Resources. 2010. Agricultural water use. Online at *www.water.ca.gov/wateruseefficiency/agricultural/*, accessed on March 17, 2014.

California Farm Water Coalition. 2014. Press release, March 18. Online at *http://new.farmwater.org/new/new-31814-estimate-of-unplanted-acres-jumps-to-800000-consumers-expected-to-feel-impacts/*, accessed on April 11, 2014.

California Governor's Office of Emergency Services. 2013. Governor Brown appeals denial of presidential major disaster declaration for Rim fire. Press release, December 3. Online at *http://caloesnewsroom.wordpress.com/2013/12/03/governor-brown-appeals-denial-of-presidential-major-disaster-declaration-for-rim-fire/*, accessed on February 6, 2014.

Carp, B.L. 2010. *Defiance of the patriots: The Boston Tea Party and the making of America*. New Haven, CT: Yale University Press.

Carr, M.H., M.J.S. Belton, C.R. Chapman, M.E. Davies, P. Geisslerk, R. Greenbergk, A.S. McEwenk, B.R. Tuftsk, R. Greeley, R. Sullivan, J.W. Head, R.T. PappalardoI, K.P. Klaasen, T.V. Johnson, J. Kaufman, D. Senske, J. Moore, G. Neukum, G. Schubert, J.A. Burns, P. Thomas, and J. Veverka. 1998. Evidence for a subsurface ocean on Europa. *Nature* 391:363–365. Online at *www.nature.com/nature/journal/v391/n6665/abs/391363a0.html*, accessed on February 16, 2014.

Cayan, D., M. Tyree, K.E. Kunkel, C. Castro, A. Gershunov, J. Barsugli, A.J. Ray, J. Overpeck, M. Anderson, J. Russell, B. Rajagopalan, I. Rangwala, and P. Duffy. 2013. Future climate: Projected average. In *Assessment of climate change in the Southwest United States: A report prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, 101–125. A report of the Southwest Climate Alliance. Washington, DC: Island Press. Online at *www.globalchange.gov/what-we-do/assessment/nca-activities/available-technical-inputs*, accessed on November 13, 2013.

Chaikin, A. 2009. How the spaceship got its shape. *Air and Space Magazine*. Online at *http://www.airspacemag.com/space/how-the-spaceship-got-its-shape-137293282/?c=y%3Fno-ist*, accessed on February 17, 2014.

Chief, K., T.P.A. Ferré, and B. Nijssen. 2008. Examination of correlation between air permeability and saturated hydraulic conductivity in unburned and burned desert soils. *Soil Science Society of America Journal* 72:1–9.

Chinese, V. 2013. Ellis Island reopens one year after Sandy. *New York Daily News*, October 28. Online at *www.nydailynews.com/new-york/hurricane-sandy/ellis-island-reopens-year-sandy-article-1.1499214*, accessed on October 27, 2013.

Church, J.A., P.U. Clark, A. Cazenave, J.M. Gregory, S. Jevrejeva, A. Levermann, M.A. Merrifield, G.A. Milne, R.S. Nerem, P.D. Nunn, A.J. Payne, W.T. Pfeffer, D. Stammer, and A.S. Unnikrishnan. 2013. Sea level change. In *Climate change 2013: The physical science basis*. Contribution of Working Group I to the fifth assessment report of the Intergovernmental Panel on Climate Change, edited by T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley. New York: Cambridge University Press.

Church, J.A., and N.J. White. 2011. Sea-level rise from the late 19th to the early 21st century. *Surveys in Geophysics* 32(4–5):585–602.

City of Annapolis. 2011a. *Flood mitigation strategies for the city of Annapolis, MD: City Dock and Eastport area*. Annapolis, MD: Department of Neighborhood and Environmental Programs. Online at *www.annapolis.gov/docs/default-source/dnep-documents-pdfs/03-01-2011-sea-level-study.pdf?sfvrsn=4*, accessed on November 6, 2013.

City of Annapolis. 2011b. *Regulatory response to sea level rise and storm surge inundation*. Annapolis, MD: Environmental Resources Management. Online at *http://dnr.maryland.gov/CoastSmart/pdfs/Annapolis_RRSLRnSSI.pdf*, accessed on November 6, 2013.

City of Boston. 2013a. City of Boston hazard mitigation plan, draft 2013, update. Online at *www.cityofboston.gov/environment/mitigationplan.asp*, accessed on December 12, 2013.

City of Boston. 2013b. *Climate-ready Boston: Municipal vulnerability to climate change*. Climate Preparedness Task Force. Online at *http://ssuu.com/ees_boston/docs/final_report_29oct13/*, accessed on April 15, 2014.

City of Charleston. 2013a. Market Street drainage improvement project. Online at *www.charleston-sc.gov/index.aspx?NID=591*, accessed on October 14, 2013.

City of Charleston. 2013b. The Old Slave Mart Museum. Online at *www.charleston-sc.gov/index.aspx?nid=160*, accessed on October 14, 2013.

City of Charleston. No date. Why does it seem like Charleston always floods when it rains? Online at *www.charleston-sc.gov/index.aspx?NID=588*, accessed on October 14, 2013.

City of New York. 2013. *A stronger, more resilient New York, PlaNYC*. Online at *www.nyc.gov/html/sirr/html/report/report.shtml*, accessed on October 27, 2013.

City of St. Augustine 2011. St. Augustine seawall flood mitigation project. Online at *www.staugustinegovernment.com/the-city/featured-stories-archive/8_11/documents/seawallpresentation1Aa_001.pdf*, accessed April 4, 2014.

City of St. Augustine. No date (a). Flood hazard information. Online at *www.staugustinegovernment.com/businesses/flood-hazard-info.cfm*, accessed on November 19, 2013.

City of St. Augustine. No date (b). Saving the seawall: Public takes advantage of informational meeting. Online at *www.staugustinegovernment.com/the-city/featured-stories-archive/8_11/saveseawall2.cfm, accessed on April 1, 2014.*

Climate Central. 2012. The age of western wildfires. Online at *www.climatecentral.org/wgts/wildfires/Wildfires2012.pdf*, accessed on March 31, 2014.

Climate Change Science Program (CCSP). 2009. Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Washington, DC. U.S. Environmental Protection Agency. Online at *http://downloads.globalchange.gov/sap/sap4-1/sap4-1-final-report-all.pdf*, accessed April 2, 2014.

Coastal Planning & Engineering of North Carolina, Inc. 2013. *Beach management concept assessment: Town of Kitty Hawk, North Carolina*. Online at *www.townofkittyhawk.org/vertical/sites/%7B991BBDF3-791F-4435-80BA-FEB8F8D09BA4%7D/uploads/WORKING_CPENC_Board_Briefing_Sept_3_20131.pdf*, accessed on October 9, 2013.

Columbia County Chamber of Commerce. 2014. Welcome to Columbia, California! Online at *www.visitcolumbiacalifornia.com*, accessed on February 6, 2014.

Committee on Options for Preserving Cape Hatteras Lighthouse, Board on Environmental Studies and Toxicology, National Research Council. 1988. *Saving Cape Hatteras Lighthouse from the sea: Options and policy implications*. Washington, DC: National Academies Press.

Cook, P.S. 2013. *Impacts of visitor spending on the local economy: Mesa Verde National Park, 2012*. Draft, natural resource report NPS/NRSS/EQD/NRR—2013/XXX. Fort Collins, CO: National Park Service. Online at *http://home.nps.gov/meve/parkmgmt/upload/uofi_meve_local_economy_2012.pdf*, accessed on April 16, 2014.

Cubasch, U., D. Wuebbles, D. Chen, M.C. Facchini, D. Frame, N. Mahowald, and J.-G. Winther. 2013. Introduction. In *Climate change 2013: The physical science basis*. Contribution of Working Group I to the fifth assessment report of the Intergovernmental Panel on Climate Change, edited by T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley. New York: Cambridge University Press.

Cui, Y., E. Mahoney, and T. Herbowicz. 2013. Economic benefits to local communities from national park visitation, 2011. Natural resource report NPS/NRSS/ARD/NRR—2013/632. Fort Collins, CO: National Park Service. Online at *www.nature.nps.gov/socialscience/docs/NPSSystemEstimates2011.pdf*, accessed on April 11, 2014.

Dahl, T., and Stedman, S.-M. 2013. *Status and trends of wetlands in the coastal watersheds of the conterminous United States, 2004–2009*. U.S. Fish and Wildlife Service and National Marine Fisheries Service. Online at *www.fws.gov/wetlands/Documents/Status-and-Trends-of-Wetlands-In-the-Coastal-Watersheds-of-the-Conterminous-US-2004-to-2009.pdf*, accessed on December 8, 2013.

Dai, A. 2011. Drought under global warming: A review. *Wiley Interdisciplinary Reviews: Climate Change* 2:45–65.

Dasheno, W. 2012. Testimony before the Senate Energy and Natural Resources Committee. Online at *www.energy.senate.gov/public/index.cfm/files/serve?File_id=8936cce7-21d6-4435-a7b5-7cd5801abf82*, accessed on February 11, 2014.

Dean Runyan Associates, Inc. 2013. California travel impacts by county, 1992-2011. 2012 Preliminary state and regional estimates. California Travel & Tourism Commission. Online at *http://industry.visitcalifornia.com/media/uploads/files/editor/Research/CATravelImpacts2012.pdf*, accessed February 11, 2014.

DeBano, L.F. 2000. The role of fire and soil heating on water repellency in wildland environments: A review. *Journal of Hydrology* 231–232:195–206.

Desilets, S.L.E., T.P.A. Ferré, and B. Ekwurzel. 2008. Flash flood dynamics and composition in a semiarid mountain watershed. *Water Resources Research* 44, W12436.

Drye, W. 2014. Can an iconic lighthouse site be saved from the sea? Preservationists fight eroding shores on the Outer Banks. *National Geographic Daily News,* March 27. Online at *http://news.nationalgeographic.com/news/2014/03/140327-lighthouse-preservation-cape-hatteras-outer-banks/*, accessed on April 6, 2014.

Edwards, J. 2011. Barrier to aid sea wall. *St. Augustine Record,* January 31. Online at *http://staugustine.com/news/local-news/2011-01-30/barrier-aid-sea-wall#.U0_iOqJnChM*, accessed on April 17, 2014.

Eggleston, J., and J. Pope. 2013. *Land subsidence and relative sea-level rise in the southern Chesapeake Bay region*, U.S. Geological Survey circular 1392. Online at *http://dx.doi.org/10.3133/cir1392*, accessed on November 8, 2013.

Eissenberg, M. 2013. Personal communication, December 24. Mike Eissenberg is general engineer at the Denver Service Center of the National Park Service.

Elsner, J.B., J.P. Kossin, and T.H. Jagger. 2008. The increasing intensity of the strongest tropical cyclones. *Nature* 455:92–95. Online at *www.nature.com/nature/journal/v455/n7209/abs/nature07234.html*, accessed on December 8, 2013.

Emanuel, K. 2005. Increasing destructiveness of tropical cyclones over the past 30 years. *Nature* 436:686–688.

Environmental Protection Agency (EPA). No date. Climate impacts in the Southwest. Online at *www.epa.gov/climatechange/impacts-adaptation/southwest.html*, accessed on February 13, 2014.

European Space Agency. 2000. Hubble, the black hole finder. Online at *www.spacetelescope.org/news/heic0002/*, accessed on February 16, 2014.

Federal Emergency Management Agency (FEMA). 2013. Flood insurance rate map: Suffolk County. Online at *http://hazards.fema.gov/femaportal/prelimdownload/searchResult.action* (enter State=Massachusetts and County=Suffolk), accessed on December 12, 2013.

Fish and Wildlife Service (FWS). 2010. *Blackwater National Wildlife Refuge: Wildlife and habitat*. Online at *www.fws.gov/blackwater/wildlife.html*, accessed on December 8, 2013.

Fish and Wildlife Service (FWS). 2009. *Blackwater National Wildlife Refuge: Marsh loss and restoration*. Online at *www.fws.gov/northeast/climatechange/pdf/blackwatermarshloss122009.pdf*, accessed on December 8, 2013.

Fleishman, E., J. Belnap, N. Cobb, C.A.F. Enquist, K. Ford, G. MacDonald, M. Pellant, T. Schoennagel, L.M. Schmit, M. Schwartz, S. van Drunick, A.L. Westerling, A. Keyser, and R. Lucas. 2013. Natural ecosystems. In *Assessment of climate change in the southwest United States: A report prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy. Washington, DC: Island Press, 148–167. A report by the Southwest Climate Alliance. Washington, DC: Island Press. Online at *www.globalchange.gov/what-we-do/assessment/nca-activities/available-technical-inputs*, accessed on November 13, 2013.

Florida Division of Historical Resources. 1990. Chapter 10: The Caloosahatchee region. In *Florida historical contexts*. Tallahassee, FL: Florida Department of State, Division of Historical Resources. Online at *www.flheritage.com/facts/reports/contexts/*, accessed on February 16, 2014.

Francis, O.P., G.G. Panteleev, and D.E. Atkinson. 2011. Ocean wave conditions in the Chukchi Sea from satellite and *in situ* observations. *Geophysical Research Letters* 38(24):6-10.

Freeburg, A., and S. Anderson. 2012. *Human-environmental dynamics at Cape Krusenstern. 200 generations: On the beach of their time*. Final report for task agreement J8W07070032. Seattle: University of Washington. Online at *www.cfr.washington.edu/research.cesu/reports/J8W07070032_final_report.pdf*, accessed on April 8, 2014.

Fritze, J. 2013. Obama establishes Tubman Park on Eastern Shore. *Baltimore Sun,* March 25. Online at *http://articles.baltimoresun.com/2013-03-25/news/bs-md-tubman-20130325_1_tubman-park-harriet-tubman-tubman-site*, accessed on December 8, 2013.

Fung, I., and E. Wolff. 2014. *Climate change evidence and causes: An overview from the Royal Society and the U.S. National Academy of Sciences*. Online at *http://nas-sites.org/americasclimatechoices/events/a-discussion-on-climate-change-evidence-and-causes/*, accessed on October 14, 2013.

Garcia, M. 2012. *From the jaws of victory: The triumph and tragedy of César Chavez and the farm worker movement*. Berkeley, CA: University of California Press.

Gardener, S. 2012. Downtown's flooding problem not expected to improve. *The St. Augustine Record,* November 16. Online at *http://staugustine.com/news/local-news/2012-11-15/flooding-problem-most-downtown-st-augustine-not-expected-improve#.UpZguWRDvhU*, accessed on April 4, 2014.

Garfin, G., A. Jardine, R. Merideth, M. Black, and S. LeRoy. 2013. *Assessment of Climate Change in the southwest United States: A report prepared for the National Climate Assessment*. A report by the Southwest Climate Alliance. Washington, DC: Island Press. Online at *www.globalchange.gov/what-we-do/assessment/nca-activities/available-technical-inputs*, accessed on November 13, 2013.

Gershunov, A., D. Cayan, and S. Iacobellis. 2009. The great 2006 heat wave over California and Nevada: Signal of an increasing trend. *Journal of Climate* 22:6181–6203. As cited in Garfin, G., A. Jardine, R. Merideth, M. Black, and S. LeRoy, 2013. *Assessment of climate change in the southwest United States: A report prepared for the National Climate Assessment*. A report of the Southwest Climate Alliance. Washington, DC: Island Press. Online at *www.globalchange.gov/what-we-do/assessment/nca-activities/available-technical-inputs*, accessed on November 13, 2013.

Gershunov, A., and K. Guirguis. 2012. California heat waves in the present and future. *Geophysical Research Letters* 39(18):7-10.

Gershunov, A., B. Rajagopalan, J. Overpeck, K. Guirguis, D. Cayan, M. Hughes, M. Dettinger, C. Castro, R.E. Schwartz, M. Anderson, A.J. Ray, J. Barsugli, T. Cavazos, and M. Alexander. 2013. Future climate: Projected extremes. In *Assessment of climate change in the southwest United States: A report prepared for the National Climate Assessment*, edited by G. Garfin A. Jardine, R. Merideth, M. Black, and S. LeRoy, 126–147. A report of the Southwest Climate Alliance. Washington, DC: Island Press. Online at *www.globalchange.gov/what-we-do/assessment/nca-activities/available-technical-inputs*, accessed on November 13, 2013.

Goebel, T., H.L. Smith , L. DiPietro, M.R. Waters, B. Hockett, K.E. Graf , R. Gal , S.B. Slobodin, R.J. Speakman, S.G. Driese, and D.Rhode. 2013. Serpentine Hot Springs, Alaska: Results of excavations and implications for the age and significance of northern fluted points. *Journal of Archaeological Science* 40:4222–4233. Online at *http://csfa.tamu.edu/cfsa-publications/Goebel-etal2013.pdf*, accessed on February 2, 2014.

Goebel, T., M.R. Waters, and D.H. O'Rourke. 2008. The late Pleistocene dispersal of modern humans in the Americas. *Science* 319(5869): 1497–1502.Onlineat*http://csfa.tamu.edu/cfsa-publications/Goebel-Waters-Science2008-319-1497.pdf*, accessed on February 2, 2014.

Goelzer, H., P. Huybrechts, S.C.B. Raper, M.-F. Loutre, H. Goosse, and T. Fichefet. 2012. Millennial total sea-level commitments projected with the Earth system model of intermediate complexity LOVECLIM. *Environmental Research Letters*. 7:045401. Online at *http://iopscience.iop.org/1748-9326/7/4/045401/*, accessed on May 4, 2014.

Gonzalez, P. 2011. Climate change impacts and carbon in U.S. national parks. *Park Science* 28(2):10–15. Online at *www.nature.nps.gov/parkscience/archive/PDF/Article_PDFs/ParkScience28(2)Summer2011_10-15_Gonzalez_2804.pdf*, accessed on April 24, 2014.

Goodheart, A. 2011. *1861: The Civil War awakening*. New York, NY: Knopf.

Gorman, S. 2014. Drought forces California farmers to idle cropland. Reuters, February 5. Online at *www.reuters.com/article/2014/02/06/usa-drought-california-idUSL2N0LB00U20140206*, accessed on March 12, 2014.

GreatBuildings.com. (No date) Faneuil Hall. *Architecture Week*. Online at *www.greatbuildings.com/buildings/Faneuil_Hall.html*, accessed on January 21, 2014.

Grinsted, A., J.C. Moore, and S. Jevrejeva. 2012. Homogeneous record of Atlantic hurricane surge threat since 1923. *Proceedings of the National Academy of Sciences* 109(48):19601–19605.

Groveland Hotel. 2010. Brief history. Online at *http://www.groveland.com/about-us/brief-history*, accessed on February 6, 2014.

Guirguis, K., A. Gershunov, A. Tardy, and R Basu. 2013. The impact of recent heat waves on human health in California. *Journal of Applied Meteorology and Climatology* 53:3–19. Online at *http://dx.doi.org/10.1175/JAMC-D-13-0130.1*, accessed on March 12, 2014.

Guth, P. 2011. Storm surge flooding at the U.S. Naval Academy. Annapolis, MD: U.S. Naval Academy. Online at *www.usna.edu/Users/oceano/pguth/website/storm_surge/flooding.htm*, accessed on November 6, 2013.

Halainen, B. 2004. *Hurricane Isabel: The National Park Service response*. Report of the Hurricane Isabel Review Group. Washington, DC: National Park Service.

Hallegatte, S., C. Green, R.J. Nicholls and J. Corfee-Morlot. 2013. Future flood losses in major coastal cities. *Nature Climate Change* 3:802–806. Online at *www.nature.com/nclimate/journal/v3/n9/full/nclimate1979.html*, accessed on February 6, 2014.

Halvorson, T. 2005. NASA lauds shuttle fuel tank plant workers. *Florida Today*, September 14. Online at *www.space.com/1549-nasa-lauds-shuttle-fuel-tank-plant-workers.html*, accessed on December 8, 2013.

Hampton University. 2014. History of Hampton University. Online at *www.hamptonu.edu/about/history.cfm*, accessed on February 1, 2014.

Harris, E.A. 2013. A magical island loses the last of its residents. *New York Times*, October 7. Online at *www.nytimes.com/2013/10/08/nyregion/a-magical-isle-loses-the-last-of-its-residents.html*, accessed on October 27, 2013.

Historical Preservation Society of the Upper Keys. No date. *Historic Florida Indians*. Online at *www.keyshistory.org/histindians.html*, accessed on February 19, 2014.

Hoerling, M.P., M. Dettinger, K. Wolter, J. Lukas, J. Eischeid, R. Nemani, B. Liebmann, and K.E. Kunkel. 2013. Present weather and climate: Evolving conditions. In *Assessment of climate change in the southwest United States: A report prepared for the National Climate Assessment*, edited by G. Garfin, A. Jardine, R. Merideth, M. Black, and S. LeRoy, eds. Washington, DC: Island Press, 74–100. A report by the Southwest Climate Alliance. Washington, DC: Island Press. Online at *www.globalchange.gov/what-we-do/assessment/nca-activities/available-technical-inputs*, accessed on November 13, 2013.

Holland, G., and C.L. Bruyère. 2014. Recent intense hurricane response to global climate change. *Climate Dynamics* 42(3-4):617–627.

Horowitz, A.D. 2013. The effects of sea level rise on historic districts and the need for adaptation. Chapter IV: Atlantic Coast Case Studies. Master's thesis, Goucher College. Online at *http://planningmatanzas.files.wordpress.com/2013/10/horowitz_staugchapter.pdf*, accessed November 28, 2013.

Howitt, R., D. MacEwan, and J. Medellin-Azuara. 2011. Drought, jobs, and controversy: Revisiting 2009. *Agricultural and Resource Economics Update* 14(6):1–4. Online at *http://giannini.ucop.edu/media/are-update/files/issues/V14N6.pdf*, accessed on March 17, 2014.

Hoyos C.D., P.A. Agudelo, P.J. Webster, and J.A. Curry. 2010. Deconvolution of the factors contributing to the increase in global hurricane intensity. *Science* 312:94–97. Online at *www.sciencemag.org/content/312/5770/94*, accessed on November 6, 2013.

InciWeb. 2013. Rim fire: Incident updated 10/25/2013. Online at *http://inciweb.nwcg.gov/incident/3660/*, accessed on February 6, 2014.

Intergovernmental Panel on Climate Change (IPCC). 2013. Summary for policymakers. In *Climate change 2013: The physical science basis*. Contribution of Working Group I to the fifth assessment report of the Intergovernmental Panel on Climate Change, edited by T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley. New York: Cambridge University Press. Online at *www.ipcc.ch/report/ar5/wg1/*, accessed on April 4, 2014.

Intergovernmental Panel on Climate Change (IPCC). 2012. Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of Working Groups I and II of the Intergovernmental Panel on Climate Change, edited by C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley. Cambridge, UK, and New York, NY: Cambridge University Press. Online at *http://ipcc-wg2.gov/SREX/report/full-report/*, accessed on April 4, 2014.

International African American Museum. No date. Online at *www.iaamuseum.org*, accessed on December 8, 2013.

Ishi, M., M. Kimoto, K. Sakamoto, and S. Iwasaki. 2006. Steric sea level changes estimated from historical ocean subsurface temperature and salinity analyses. *Journal of Oceanography* 62:155–70.

Joyce, C. 2013. With rising seas, America's birthplace could disappear. *All Things Considered*, May 14. Online at *www.npr.org/2013/05/14/178809495/with-rising-seas-americas-birthplace-could-disappear*, accessed on November 8, 2013.

Joyner, B.D. 2009. *Hispanic reflections on the American landscape: Identifying and interpreting Hispanic heritage*. Washington, DC: National Park Service. Online at *www.nps.gov/crdi/publications/pubs.htm*, accessed on November 19, 2013.

Karl, T.R., B.E. Gleason, M.J. Menne, J.R. McMahon, R.R. Heim, M.J. Brewer, K.E. Kunkel, D.S. Arndt, J.L. Privette, J.J. Bates, P.Y. Groisman, and D.R. Easterling. 2012. U.S. temperature and drought: Recent anomalies and trends. *Eos, Transactions of the American Geophysical Union* 93(47):473.

Keener, V.W., J.J. Marra, M.L. Finucane, D. Spooner, and M.H. Smith, eds. 2012. *Climate change and Pacific islands: Indicators and impacts*. Report for the 2012 Pacific Islands Regional Climate Assessment. Washington, DC: Island Press.

Kennedy, J.F. Text of President John F. Kennedy's Rice Stadium moon speech. 1962. Online at *http://er.jsc.nasa.gov/seh/ricetalk.htm*, accessed on February 10, 2014.

Khokha, S. 2008. Teen farmworker's heat death sparks outcry. KQED, June 6. Online at *www.npr.org/templates/story/story.php?storyId=91240378*, accessed on March 12, 2014.

King, C.T., M. Anderson, E. Evans, B. Hadley, J.B. Kellison, A. Merjanian, T. Smith, and A. Stackhouse. 2007. *Economic and workforce impacts of Hurricane Katrina, demographic and related changes on NASA's space shuttle program: Findings and recommendations*. Austin, TX: Ray Marshall Center for the Study of Human Resources and IC2 Institute, University of Texas. Online at *http://repositories.lib.utexas.edu/bitstream/handle/2152/14469/king-2007-katrina-nasa-final-report.pdf?sequence=3*, accessed on December 8, 2013.

Knutson, T.R., J.L. McBride, J. Chan, K. Emanuel, G. Holland, C. Landsea, I. Held, J.P. Kossin, A.K. Srivastava, and M. Sugi. 2010. Tropical cyclones and climate change. *Nature Geoscience* 3:157–163.

Korfhage, S. 2012. Renourishment gives St. Augustine Beach a new look. *St. Augustine Record*, September 9. Online at *http://staugustine.com/news/local-news/2012-09-12/renourishment-gives-st-augustine-beach-new-look*, accessed on November 19, 2013.

Koumoudis, V., C. Jones, L. Tanner, and W. Wilson. 2009. *Hurricane Ike in Texas and Louisiana: Mitigation assessment team report*. Federal Emergency Management Center (FEMA). Online at *www.fema.gov/media-library-data/20130726-1648-20490-1790/757_ch1_final.pdf*, accessed on December 8, 2013.

Kowalski, M. No date. Rising seas threaten national landmarks on the Chesapeake Bay. Online at *http://cnsmaryland.org/sealevelrise/?p=131*, accessed on December 8, 2013.

Kunkel, K., L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, C.E. Konrad II, C.M. Fuhrman, B.D. Keim, M.C. Kruk, A. Billet, H. Needham, M. Schafer, and J.G. Dobson. 2013a. *Regional climate trends and scenarios for the U.S. National Climate Assessment. Part 2. Climate of the Southeast*. NOAA technical report NESDIS 142-2. Online at *www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-2-Climate_of_the_Southeast_U.S.pdf*, accessed on February 2, 2014.

Kunkel, K.E., T.R. Karl, H. Brooks, J. Kossin, J.H. Lawrimore, D. Arndt, L. Bosart, D. Changnon, S.L. Cutter, N. Doesken, K. Emanuel, P.Y. Groisman, R.W. Katz, T. Knutson, J. O'Brien, C.J. Paciorek, T.C. Peterson, K. Redmond, D. Robinson, J. Trapp, R. Vose, S. Weaver, M. Wehner, K. Wolter, and D. Wuebbles. 2013b. Monitoring and understanding trends in extreme storms: State of knowledge. *Bulletin of the American Meteorological Society* 94(4):499–514.

Kunkel, K.E., L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, S.D. Hilberg, M.S. Timlin, L. Stoecker, N.E. Westcott, and J.G. Dobson. 2013c. *Regional climate trends and scenarios for the U.S. national climate assessment. Part 3. Climate of the Midwest U.S.* NOAA technical report NESDIS 142-3. Online at *www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-3-Climate_of_the_Midwest_U.S.pdf*, accessed April 29, 2014.

Larsen, C., I. Clark, G. Guntenspergen, D. Cahoon, V. Caruso, C. Hupp, and T. Yanosky. 2004. *The Blackwater NWR Inundation Model. Rising sea level on a low-lying coast: Land use planning for wetlands*, report 04-1302. U.S. Geological Survey. Laurel, MD: Patuxent Wildlife Research Center. Online at *http://pubs.usgs.gov/of/2004/1302/*, accessed on December 8, 2013.

Larsen, K.C. 2004. *Bound for the promised land: Harriet Tubman: Portrait of an American hero*. New York: Ballentine.

Lelis, L. 2008. A rare moment to raise history: New boardwalk at Turtle Mound opens windows to past. *Orlando Sentinel*, April 29. Online at *http://articles.orlandosentinel.com/2008-04-29/news/mound29_1_turtle-mound-mound-was-built-new-boardwalk*, accessed on February 19, 2014.

Li, M., L. Zhong, W.C. Boicourt, S. Shunli Zhang, and D.-L. Zhang. 2006. Hurricane-induced storm surges, currents, and destratification. *Geophysical Research Letters* 33(2) L02604.

Magee, R. 2011. *Case study and lessons learned associated with Hurricane Katrina, August 29, 2005*. Hancock County, MS: John C. Stennis Space Center.

Markon, C.J., S.F. Trainor, and F.S. Chapin, III. 2012. *The United States National Climate Assessment—Alaska technical regional report*, U.S. Geological Survey circular 1379. Washington, DC: Department of the Interior. Online at *http://pubs.usgs.gov/circ/1379/*, accessed on February 2, 2014.

Maryland Department of Natural Resources. No date. Harriet Tubman Underground Railroad State Park. Online at *www.dnr.state.md.us/publiclands/eastern/tubman.asp*, accessed on December 8, 2013.

Maryland Historical Trust. 2013. Certified local government subgrant program. In *Cultural resource hazard mitigation plan for the Annapolis historic district*. Federal grant application from the Maryland Historical Trust/City of Annapolis.

Masson-Delmotte, V., M. Schulz, A. Abe-Ouchi, J. Beer, A. Ganopolski, J.F. González Rouco, E. Jansen, K. Lambeck, J. Luterbacher, T. Naish, T. Osborn, B. Otto-Bliesner, T. Quinn, R. Ramesh, M. Rojas, X. Shao, and A. Timmermann. 2013. Information from paleoclimate archives. In *Climate change 2013: The physical science basis*. Contribution of Working Group I to the fifth assessment report of the Intergovernmental Panel on Climate Change, edited by T.F. Stocker D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley, New York: Cambridge University Press.

McWilliams, J.W. 2011. *Annapolis, city on the Severn: A history*. Baltimore: Johns Hopkins University Press.

Melillo, J.M., T. Richmond, and G.W. Yohe, eds. 2014: *Highlights of climate change impacts in the United States: The third national climate assessment*. United States Global Change Research Program. Online at *http://nca2014.globalchange.gov/highlights*, accessed on May 6, 2014.

Merrill, L. 2001. Controlling erosion after the fire's out: A case study of Mesa Verde National Park. *Erosion Control* 8(1). Online at *www.erosioncontrol.com/EC/Articles/Controlling_Erosion_After_the_Fires_Out_A_Case_Stu_4792.aspx*, accessed on November 18, 2013.

Miller, K.G., R.E. Kopp, B.P. Horton, J.V. Browning, and A.C. Kemp. 2013. A geological perspective on sea-level rise and its impacts along the U.S. mid-Atlantic coast. *Earth's Future* 1(1):3–18.

Mitchell. M., E. Eggington, C. Hershner, J. Herman, D. Schatt, and S. Stiles. 2013. *Recurrent flooding study for tidewater Virginia*. Report submitted by the Virginia Institute of Marine Science to the Virginia General Assembly. Online at *http://leg2.state.va.us/dls/h&sdocs.nsf/4d54200d7e28716385256ec1004f3130/43c5b6688601e52c852579c900531e82?OpenDocument*, accessed on February 1, 2014.

Morales, M. 2013. Rim fire crosses the 100k acre mark. Online at *www.firefighterblog.com/2013/08/23/rim-fire-crosses-the-100k-acre-mark/*, accessed on March 31, 2014.

The Mound House. No date. The Caloosahatchee period (ca. 500 B.C.–1750 A.D.). Fort Myers Beach, FL. Online at *www.moundhouse.org/index.php/information/2-000-years-of-history-timeline/the-caloosahatchee-period*, accessed on February 19, 2014.

National Aeronautics and Space Administration (NASA). 2014a. Goddard Space Flight Center: Present missions. Online at *www.nasa.gov/centers/goddard/missions/index.html#.U1VdiOZdURg*, accessed on April 21, 2014.

National Aeronautics and Space Administration (NASA). 2014b. Hubble space telescope. Online at *www.nasa.gov/mission_pages/hubble/main/index.html*, accessed on February 15, 2014.

National Aeronautics and Space Administration (NASA). 2014c. NASA helps growers during California's drought. Press release, February 25. Online at *www.nasa.gov/ames/nasa-helps-growers-during-californias-drought/#.UysWQOddXy1*, accessed on March 12, 2014.

National Aeronautics and Space Administration (NASA). 2013a. Apollo: Humankind's first steps on the lunar surface. Online at *www.nasa.gov/mission_pages/apollo/index.html*, accessed on February 11, 2014.

National Aeronautics and Space Administration (NASA). 2013b. Gemini: Stepping stone to the moon. Online at *www.nasa.gov/mission_pages/gemini/index.html*, accessed on February 11, 2014.

National Aeronautics and Space Administration (NASA). 2013c. Langley Research Center. Online at *www.nasa.gov/centers/langley/home/index.html*, accessed on December 8, 2013.

National Aeronautics and Space Administration (NASA). 2013d. Mercury: America's first astronauts. Online at *www.nasa.gov/mission_pages/mercury/index.html*, accessed on February 11, 2014.

National Aeronautics and Space Administration (NASA). 2013e. NASA Wallops recovery continues from Hurricane Sandy. March 5. Online at *www.nasa.gov/mission_pages/hurricanes/features/wallops-sandy.html*, accessed on December 8, 2013.

National Aeronautics and Space Administration (NASA). 2013f. Skylab: America's first space station. Online at *www.nasa.gov/mission_pages/skylab/index.html,* accessed on February 15, 2014.

National Aeronautics and Space Administration (NASA). 2013g. Space shuttle. Online at *www.nasa.gov/mission_pages/shuttle/main/index.html,* accessed on February 11, 2014.

National Aeronautics and Space Administration (NASA). 2012a. *Adapting now to a changing climate: Wallops Flight Facility and the Eastern Shore.* Report NP-2012-10-909-HQ. Climate Adaptation Science Investigator Work Group. Online at *www.hq.nasa.gov/office/codej/codejx/Assets/Docs/NASA_Wallops_Climate%20Info_Web.pdf,* accessed February 11, 2014.

National Aeronautics and Space Administration (NASA). 2012b. Record-setting X-ray jet discovered. Online at *www.nasa.gov/mission_pages/chandra/news/xray_jet.html,* accessed on February 15, 2014.

National Aeronautics and Space Administration (NASA). 2011a. *Kennedy Space Center: Future development concept 2012–2031.* KSC Center Planning and Development Office. Online at *www.nasa.gov/centers/kennedy/pdf/634026main_future-concept.pdf,* accessed on February 11, 2014.

National Aeronautics and Space Administration (NASA). 2011b. *NASA strategic plan.* Office of the Chief Financial Officer. Online at *www.nasa.gov/offices/ocfo/budget/strat_plans.html,* accessed on December 8, 2013.

National Aeronautics and Space Administration (NASA). 2010. *Adapting now to a changing climate: Florida's space coast.* Report NP-2010-11-687-HQ. Online at *www.hq.nasa.gov/office/codej/codejx/Assets/Docs/KSC%20Climate%20Handout%20for%20web.pdf,* accessed February 11, 2014.

National Aeronautics and Space Administration (NASA). 2009. Apollo 11. Online at *www.nasa.gov/mission_pages/apollo/missions/apollo11.html#.Uvu0i_s0-KI,* accessed on February 11, 2014.

National Aeronautics and Space Administration (NASA). 2007. Sputnik: The fiftieth anniversary. Online at *http://history.nasa.gov/sputnik/,* accessed on February 11, 2014.

National Aeronautics and Space Administration (NASA). 2004a. Historical backgrounder: NASA Ames Research Center. Online at *http://history.arc.nasa.gov/backgrounder.htm,* accessed on February 14, 2014.

National Aeronautics and Space Administration (NASA). 2004b. Release: 04-301: Kennedy Space Center recovers from Hurricane Frances. *NASA News.* Online at *www.nasa.gov/home/hqnews/2004/sep/HQ_04301_FrancesRecovery.html,* accessed on May 4, 2014.

National Aeronautics and Space Administration (NASA). 2002. Science news: Found it! Ice on Mars. Online at *http://science1.nasa.gov/science-news/science-at-nasa/2002/28may_marsice/,* accessed on February 15, 2014.

National Aeronautics and Space Administration (NASA). No date (a). Earth: Your future, our mission. Online at *www.nasa.gov/topics/earth/index.html#.UwvJTfs0-KI,* accessed on February 12, 2014.

National Aeronautics and Space Administration (NASA). No date (b). Launch schedule. Online at *www.nasa.gov/missions/schedule/#.UvEirvs0-KI,* accessed on February 10, 2014.

NASA Goddard Institute for Space Studies. 2014. Overview. Online at *www.giss.nasa.gov/,* accessed on February 12, 2014.

NASA Jet Propulsion Laboratory. No date. First space missions: Mariners to Venus. Online at *www.jpl.nasa.gov/jplhistory/mission/venus-t.php,* accessed on February 15, 2014.

NASA John C. Stennis Space Center. No date. Stennis is... Online at *www.nasa.gov/centers/stennis/about/stennis/index.html,* accessed on February 14, 2014.

NASA Johnson Space Center. 2008. Hurricane Ike edition. *Roundup,* November. Online at *www.jsc.nasa.gov/roundup/online/2008/1108.pdf,* accessed on December 8, 2013.

NASA Langley Research Center. No date. Delivering for today ... Preparing for tomorrow. Online at *www.norfolk.gov/DocumentCenter/View/1767,* accessed on December 8, 2013.

NASA Marshall. 2013. NASA Marshall Space Flight Center: Michoud Assembly Facility. Online at *www.nasa.gov/centers/marshall/michoud/#.UquThmRDvy0,* accessed on February 13, 2014.

NASA Office of Inspector General. 2011. *NASA's use of Recovery Act funds to repair hurricane damage at Johnson Space Center.* Report Ig-11-025. Online at *http://oig.nasa.gov/audits/reports/FY11/IG-11-025.pdf,* accessed on December 8, 2013.

NASA Wallops Flight Facility. 2012. Wallops' newest beach. Online at *www.nasa.gov/centers/wallops/news/beach.html,* accessed on December 8, 2013.

National Drought Mitigation Center. 2014. U.S. drought monitor: California. 2014. Online at *droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?CA,* accessed on March 18, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014a. Climate at a glance: Time series. California. Precipitation. Climate Division 5: San Joaquin drainage. Online at *www.ncdc.noaa.gov/cag/,* accessed on March 13, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014b. Climate at a glance: Time series. Colorado. Temperature, 1895–2013. Climate Division 2: Colorado drainage. Online at *www.ncdc.noaa.gov/cag/,* accessed on March 25, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014c. Climate at a glance: Time series. Contiguous U.S. Temperature, 1895–2013. Online at *www.ncdc.noaa.gov/cag/time-series/us/110/00/tmp/12/12/1895-2013?base_prd=true&firstbaseyear=1901&lastbaseyear=2000&trend=true&trend_base=10&firsttrendyear=1895&lasttrendyear=2013,* accessed on April 5, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014d. Climate at a glance: Time series. Contiguous U.S. Temperature, 1949–2013. Online at *www.ncdc.noaa.gov/cag/*, accessed on April 24, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014e. Climate at a glance: Time series. Global land and ocean temperature anomalies, 1880–2013. Online at *www.ncdc.noaa.gov/cag/time-series/global*, accessed on April 24, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014f. Mean sea level trends. Online at *http://tidesandcurrents.noaa.gov/sltrends/sltrends.html*, accessed on April 11, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014g. Mean sea level trends: Fernandina Beach, Naples, and Key West, Florida. Online at *http://tidesandcurrents.noaa.gov/sltrends/sltrends.html*, accessed on February 2, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014h. NOAA/NOS/CO-OPS observed water levels at 8443970, Boston MA. Online at *http://tidesandcurrents.noaa.gov/waterlevels.html?id=8443970*, accessed on February 12, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014i. NOAA/NOS/CO-OPS observed water levels at 8575512, Annapolis MD. Online at *http://tidesandcurrents.noaa.gov/waterlevels.html?id=8575512*, accessed on March 27, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014j. NOAA/NOS/CO-OPS observed water levels at 8638610 Sewells Point, VA for September 18, 2003, and August 27, 2011. Online at *http://tidesandcurrents.noaa.gov/waterlevels.html?id=8638610*, accessed on February 12, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014k. Sea level rise and coastal flooding impacts. Online at *www.csc.noaa.gov/slr/viewer/#*, accessed on April 8, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014l. Updated mean sea level trends 1617760 Hilo, Hawaii. Online at *http://tidesandcurrents.noaa.gov/sltrends/sltrends_update.shtml?stnid=1617760*, accessed on April 8, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2014m. Updated mean sea level trends 8638610 Sewells Point, VA. Online at *http://tidesandcurrents.noaa.gov/sltrends/sltrends_update.shtml?stnid=8638610*, accessed on February 1, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2013a. Extreme water levels. Boston 8443970. Online at http://*tidesandcurrents.noaa.gov/est/northatlantic.html*, accessed on December 12, 2013.

National Oceanic and Atmospheric Administration (NOAA). 2013b. Mean sea level trend: 8761724 Grand Isle, Louisiana. Online at *http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8761724*, accessed on April 18, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2013c. Mean sea level trend: 8571892 Cambridge, Maryland: 1943–2006. Online at *http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8571892*, accessed on December 8, 2013.

National Oceanic and Atmospheric Administration (NOAA). 2013d. Mean sea level trend: 8632200 Kiptopeke, Virginia. Online at *http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8632200*, accessed on December 8, 2013.

National Oceanic and Atmospheric Administration (NOAA). 2013e. Mean sea level trend: 8665530 Charleston, South Carolina. Online at *http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8665530*, accessed on April 18, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2013f. Mean sea level trend: 8720218 Mayport, Florida. Online at *http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8720218*, accessed on November 19, 2013.

National Oceanic and Atmospheric Administration (NOAA). 2013g. Sea level rise and coastal flooding impacts. Online at *http://csc.noaa.gov/slr/viewer/*, accessed on November 19, 2103.

National Oceanic and Atmospheric Administration (NOAA). 2013h. Updated mean sea level trends: 8518750 The Battery, New York, 1856–2012. Online at *http://tidesandcurrents.noaa.gov/sltrends/sltrends_update.shtml?stnid=8518750*, accessed on October 27, 2013.

National Oceanic and Atmospheric Administration (NOAA). 2013i. Verified hourly heights at 8575512, Annapolis, MD. Hurricane Isabel 2003 on 9/19/2003 at 12:00 GMT. Online at *http://tidesandcurrents.noaa.gov/waterlevels.html?id=8575512&units=standard&bdate=20030917&edate=20030920&timezone=GMT&datum=MLLW&interval=h&action*, accessed on November 6, 2013.

National Oceanic and Atmospheric Administration (NOAA). 2013j. Water level report: Monthly max-min report: Severn River, Annapolis, MD 8575512. Online at *http://tidesandcurrents.noaa.gov/reports.html?type=monthlyextremes&bdate=19300101&edate=20131231&units=standard&id=8575512&retrieve=Retrieve*, accessed on November 6, 2013.

National Oceanic and Atmospheric Administration (NOAA). 2012. Observing Hurricane Sandy like a meteorologist. Online at *www.sos.noaa.gov/Education/sandy.html*, accessed on October 27, 2013.

National Park Service (NPS). 2013a. Ellis Island: Plan your visit: Visitor alert. Online at *www.nps.gov/elis/planyourvisit/index.htm*, accessed on October 27, 2013.

National Park Service (NPS). 2013b. Final César Chávez special resource study. Online at *http://parkplanning.nps.gov/Final_Cesar_Chavez_Study*, accessed on November 4, 2013.

National Park Service (NPS). 2013c. Rim fire 2013: Burned area emergency response plan. Online at *www.nps.gov/yose/parkmgmt/upload/RIM_BAER_PLAN2013.pdf*, accessed on February 6, 2014.

National Park Service (NPS). 2013d. Statue of Liberty National Monument and Ellis Island. Recovery after Hurricane Sandy. Online at *www.nps.gov/stli/after-hurricane-sandy.htm*, accessed on October 27, 2013.

National Park Service (NPS). 2010. *National Park Service climate change response strategy*. Fort Collins, CO: Climate Change Response Program of the NPS. Online at *www.nature.nps.gov/climatechange/docs/NPS_CCRS.pdf*, accessed on March 23, 2014.

National Park Service (NPS). 2009. Mesa Verde: Fire history. Online at *www.nps.gov/meve/parkmgmt/upload/fire_history_09.pdf*, accessed on November 18, 2013.

National Park Service (NPS). 2007a. Archeology and fire. Online at *www.nps.gov/meve/parkmgmt/upload/arch_fire_effects.pdf*, accessed on March 25, 2014.

National Park Service (NPS). 2007b. Cape Krusenstern beach ridge complex survey. Online at *www.cr.nps.gov/archeology/sites/npSites/capeKrusenstern.htm*, accessed on February 2, 2014.

National Park Service (NPS). 1987. *The architectural heritage of Fort Monroe, volume 1*. Online at *www.nps.gov/history/history/online_books/nnps/fort_monroe.pdf*, accessed on February 1, 2104.

National Park Service (NPS). No date (a). American Latino heritage: Castillo de San Marcos National Monument, St. Augustine, Florida. Online at *www.nps.gov/history/nr/travel/american_latino_heritage/Castillo_de_San_Marcos_National_Monument.html*, accessed on November 19, 2013.

National Park Service (NPS). No date (b). American Latino heritage: Fort Mose site, Florida. Online at *www.nps.gov/history/nr/travel/american_latino_heritage/Fort_Mose.html*, accessed on November 19, 2013.

National Park Service (NPS). No date (c). Ancestral Puebloans and their world. Online at *www.nps.gov/meve/forteachers/upload/ancestral_puebloans.pdf*, accessed on February 12, 2014.

National Park Service (NPS). No date (d). Bandelier National Monument. Online at *www.nps.gov/band/index.htm*, accessed on February 13, 2014.

National Park Service (NPS). No date (e). Bering Land Bridge National Preserve. Online at *www.nps.gov/bela/historyculture/index.htm*, accessed on February 23, 2014.

National Park Service (NPS). No date (f). Boston National Historical Park: Faneuil Hall. Online at *www.nps.gov/bost/historyculture/fh.htm*, accessed on January 21, 2014.

National Park Service (NPS). No date (g). César E. Chávez National Monument. Online at *www.nps.gov/cech/index.htm*, accessed on November 4, 2013.

National Park Service (NPS). No date (h). Charleston & preservation (excerpted from Chase, C.E. 1998. Charleston: Guarding her customs, buildings, and laws. *Preservation Forum, Fall*). Online at *www.nps.gov/nr/travel/charleston/preservation.htm*, accessed on October 14, 2013.

National Park Service (NPS). No date (i). Ellis Island. Online at *www.nps.gov/elis/index.htm*, accessed on October 27, 2013.

National Park Service (NPS). No date (j). Everglades: How else is South Florida affected? Online at *www.nps.gov/ever/naturescience/cceffectsnearparkobs.htm*, accessed on February 16, 2014.

National Park Service (NPS). No date (k). Fort Monroe National Monument. Online at *www.nps.gov/fomr/index.htm*, accessed on February 1, 2014.

National Park Service (NPS). No date (l). Fort Sumter National Monument. Online at *www.nps.gov/fosu/index.htm*, accessed on January 21, 2014.

National Park Service (NPS). No date (m). Historic Jamestowne. Online at *www.nps.gov/jame/index.htm*, accessed on November 8, 2013.

National Park Service (NPS). No date (n). The Las Conchas fire. Online at *www.nps.gov/band/naturescience/lasconchas.htm*, accessed on February 15, 2014.

National Park Service (NPS). No date, (o) Lost to the perils of the sea. Online at *www.nps.gov/caha/historyculture/shipwrecks.htm*, accessed on April 6, 2014.

National Park Service (NPS). No date (p). Mesa Verde National Park. Online at *www.nps.gov/meve/index.htm*, accessed on November 18, 2013.

National Park Service (NPS). No date (q). Moving the Cape Hatteras Lighthouse. Online at *www.nps.gov/caha/historyculture/movingthelighthouse.htm*, accessed on April 6, 2014.

National Park Service (NPS). No date (r). National historic landmarks program: Fort Monroe. Online at *http://tps.cr.nps.gov/nhl/detail.cfm?ResourceId=691&ResourceType=District*, accessed on February 1, 2014.

National Park Service (NPS). No date (s). Pu'uhonua o Hōnaunau National Historical Park. Online at *www.nps.gov/puho/index.htm*, accessed on December 4, 2013.

National Park Service (NPS). No date (t). St. Augustine: Lincolnville Historic District. Online at *www.nps.gov/NR/travel/geo-flor/28.htm*, accessed on April 4, 2014.

National Park Service (NPS). No date (u). Statue of Liberty National Monument. Online at *www.nps.gov/stli/index.htm*, accessed on October 27, 2013

National Parks Conservation Association (NPCA). 2007. *Unnatural disaster: Global warming and our national parks*. Online at *www.npca.org/assets/pdf/unnatural_disaster_2.pdf*, accessed on November 8, 2013.

National Parks Conservation Association (NPCA). No date. Fort Sumter National Monument: A resource assessment. Online at *www.npca.org/about-us/center-for-park-research/stateoftheparks/fort_sumter/FOSU-web.pdf*, accessed on October 14, 2013.

National Public Radio. 2013. Iron Door Saloon. Online at *www.npr.org/2013/08/28/216355790/so-far-iron-door-saloon-stays-open-during-rim-fire*, accessed on February 6, 2014.

National Snow and Ice Data Center (NSIDC). 2013. A better year for the cryosphere. *Arctic Sea Ice News & Analysis*. October 3. Online at *http://nsidc.org/arcticseaicenews/2013/10/a-better-year-for-the-cryosphere/*, accessed on February 2, 2014.

National Weather Service (NWS). 2014. Advanced hydrologic prediction service. James River at Sewells Point. Online at *http://water.weather.gov/ahps2/hydrograph.php?wfo=akq&gage=swpv2*, accessed on December 8, 2013.

National Weather Service (NWS). 2013. Historical rainfall event, Sandoval County. Online at *www.srh.noaa.gov/abq/?n=2013SeptemberFlooding-SandovalCounty*, accessed on February 13, 2014.

Nisengard, J.E., B.C. Harmon, K.M. Schmidt, A.L. Madsen, W.B. Masse, E.D. McGehee, K.L.M. Garcia, J. Isaacson, and J.S. Dean. 2002. *Cerro Grande Fire Assessment Project: An assessment of the impact of the Cerro Grande fire on cultural resources at Los Alamos National Laboratory, New Mexico.* Los Alamos National Laboratory, report LA-UR-02-5713. Online at *http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-02-5713*, accessed on February 13, 2014.

North Carolina Department of Transportation (NCDOT). No date. Long-term solutions for N.C. 12 breaches. Online at *www.ncdot.gov/projects/bonnerbridgephase2/*, accessed January 19, 2014.

Nultemeier, B. 2013. Relentless March storm pounds the Outer Banks. *OBXSurfInfo.com*, March 12. Online at *www.obxsurfinfo.com/2013/03/12/relentless-march-storm-pounds-the-outer-banks-photo-gallery/*, accessed on October 9, 2013.

Occupational Safety & Health Administration (OSHA). No date. Heat fatalities. Online at *www.osha.gov/SLTC/heatillness/map_text.html*, accessed on March 13, 2014.

Office of Environmental Health Hazard Assessment. 2013. Indicators of climate change in California. California Environmental Protection Agency. Online at *www.oehha.ca.gov/multimedia/epic/2013EnvIndicatorReport.html*, accessed on March 12, 2014.

Office of Tourism Analysis, College of Charleston. 2012. Estimation of tourism economic impacts in the Charleston area, 2011. Online at *www.charlestonchamber.net/resources/economic-community-data*, accessed on October 14, 2013.

O'Leary, K. 2009. Fatal sunshine: The plight of California's farm workers. *Time*, August 8. Online at *http://content.time.com/time/nation/article/0,8599,1914961,00.html*, accessed on March 13, 2014.

Oster, E.A., S. Ruscavage-Barz, and M.L. Elliott. 2012. Chapter 7: The Effects of Fire on Subsurface Archaeological Materials. In United States Department of Agriculture Forest Service General Technical Report RMRS-GTR-42-vol. 3. 2012. Online at *www.fs.fed.us/rm/pubs/rmrs_gtr042_3/rmrs_gtr042_3_143_156.pdf*, accessed on May 4, 2014.

Overpeck, S. 2009. Hurricane Ike wind analysis for Southeast Texas. NOAA/NWS Houston/Galveston. Online at *www.srh.noaa.gov/hgx/?n=projects_ike08_wind_analysis*, accessed on December 8, 2013.

Pagani, M., Z. Liu, J. LaRiviere, and A.C. Ravelo. 2010. High Earth-system climate sensitivity determined from Pliocene carbon dioxide concentrations. *Nature Geoscience* 3:27–30. Online at *www.nature.com/ngeo/journal/v3/n1/full/ngeo724.html*, accessed on December 4, 2013.

Papenfuse, E.C. 1975. *In pursuit of profit: The Annapolis merchants in the era of the American revolution, 1763–1805.* Baltimore: Johns Hopkins University Press.

Parker, S. 2008. Canaveral National Seashore: Historic resource study. Washington, DC: National Park Service.

Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti,R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. 2012. *Global sea level rise scenarios for the United States National Climate Assessment.* NOAA Tech Memo OAR CPO-1. Online at *http://cpo.noaa.gov/sites/cpo/Reports/2012/NOAA_SLR_r3.pdf*, accessed on October 27, 2013.

Perry, G. 2013. Reasons to consider storm damage reduction through beach nourishment. Town of Kitty Hawk. Online at *www.townofkittyhawk.org/vertical/sites/%7B991BBDF3-791F-4435-80BA-FEB8F8D09BA4%7D/uploads/Gary_Perry__Presentation_REASONS_TO_CONSIDER_STORM_DAMAGE_REDUCTION_THROUGH_BEACH1.pdf*, accessed on April 6, 2014.

Presidential proclamation: Establishment of the Harriet Tubman Underground Railroad National Monument. 2013. Online at *www.whitehouse.gov/the-press-office/2013/03/25/presidential-proclamation-harriet-tubman-underground-railroad-national-m*, accessed on December 8, 2013.

Pryor, S.C., J.A. Howe, and K.E. Kunkel. 2009. How spatially coherent and statistically robust are temporal changes in extreme precipitation in the contiguous USA? *International Journal of Climatology* 29(1):31–45.

Quinn, D.B. 1985. *Set fair for Roanoke: Voyages and colonies, 1584–1606.* Chapel Hill, NC: UNC Press Books.

Reich, D., N. Patterson, D. Campbell, A. Tandon, S. Mazieres, N. Ray, M.V. Parra, W. Rojas, C. Duque, N. Mesa, L.F. García, O. Triana, S. Blair, A. Maestre, J.C. Dib, C.M. Bravi, G. Bailliet, D. Corach, T. Hünemeier, M C. Bortolini, F.M. Salzano, M.L. Petzl-Erler, V. Acuña-Alonzo, C. Aguilar-Salinas, S. Canizales-Quinteros, T. Tusié-Luna, L. Riba, M. Rodríguez-Cruz, M. Lopez-Alarcón, R. Coral-Vazquez, T. Canto-Cetina, I. Silva-Zolezzi, J.C. Fernandez-Lopez, A.V. Contreras, G. Jimenez-Sanchez, M.J. Gómez-Vázquez, J. Molina, Á. Carracedo, A. Salas, C. Gallo, G. Poletti, D.B. Witonsky, G. Alkorta-Aranburu, R.I. Sukernik, L. Osipova, S.A. Fedorova, R. Vasquez, M. Villena, C. Moreau, R. Barrantes, D. Pauls, L. Excoffier, G. Bedoya, F. Rothhammer, J.-M. Dugoujon, G. Larrouy, W. Klitz, D. Labuda, J. Kidd, K. Kidd, A. Di Rienzo, N.B. Freimer, A.L. Price, and A. Ruiz-Linares. 2012. Reconstructing Native American population history. *Nature* 488(7411):370–374. Online at *www.nature.com/nature/journal/v488/n7411/full/nature11258.html*, accessed on February 23, 2014.

Roberts, J. 2003. Langley stands up to Isabel. *NASA Researcher News*, October 10. Online at *http://researchernews.larc.nasa.gov/archives/2003/101003/Isabel.html*, accessed on December 8, 2013.

Rodriguez, R. 2013. Field worker's suspected heat-related death closes South Valley farm. *Fresno Bee*, July 9. Online at *www.fresnobee.com/2013/07/09/3380842/south-valley-farm-shut-down-after.html*, accessed on March 13, 2014.

Rogers, R. 2003. Isabel rewrites Fort Monroe history. *The Daily Press*, September 23. Online at *http://articles.dailypress.com/2003-09-23/news/0309230056_1_unexploded-shells-and-bombs-moat-hurricane-isabel*, accessed on February 1, 2014.

Russo, T.A., A.T. Fisher, and D.M. Winslow. 2013. Regional and local increases in storm intensity in the San Francisco Bay Area, USA, between 1890 and 2010. *Journal of Geophysical Research: Atmospheres* 118(8):3392–3401.

Sallenger, A.H., Jr., K.S. Doran, and P.A. Howd. 2012. Hotspot of accelerated sea-level rise on the Atlantic coast of North America. *Nature Climate Change* 2:884–888. Online at *www.nature.com/nclimate/journal/v2/n12/full/nclimate1597.html*, accessed on April 11, 2014.

Samenow, J. 2011. The National Hurricane Center's strikingly accurate forecast for Sandy. *Washington Post*, November 1. Online at *www.washingtonpost.com/blogs/capital-weather-gang/post/the-national-hurricane-centers-striking-forecast-for-superstorm-sandy/2012/11/01/e2633b5e-2427-11e2-ac85-e669876c6a24_blog.html*, accessed on December 8, 2013.

San Joaquin Valley Air District. No date. Frequently asked questions. Online at *www.valleyair.org/General_info/Frequently_Asked_Questions.htm*, accessed on March 17, 2014.

Saunders, S., T. Easley, and T. Spencer. 2010. *Virginia special places in peril: Jamestown, Chincoteague, and Shenandoah threatened by climate disruption*. Louisville, CO, and New York, NY: Rocky Mountain Climate Organization and Natural Resources Defense Council.

Scharroo, R., W.H.F. Smith, and J.L. Lillibridge. 2005. Satellite altimetry and the intensification of Hurricane Katrina. *Eos, Transactions American Geophysical Union* 86(40):366.

Schwadron, M. 2009. *Maritime landscapes of complexity: Prehistoric shell works and the rise of social complexity among coastal foragers in south Florida*. Tallahassee, FL: National Park Service, Southeast Archeological Center.

Scripps Institution of Oceanography. No date. The Keeling curve. Online at *keelingcurve.ucsd.edu*, accessed on March 11, 2014.

Seager, R., M. Ting, C. Li, N. Naik, B. Cook, J. Nakamura, and H. Liu. 2013. Projections of declining surface water availability for the southwestern United States. *Nature Climate Change* 3:482–486.

Selverston, A. 2011. In bracing Moffett Field for climate impacts, NASA offers brainpower to bay cities. *Millbrae Patch*, February 7. Online at *http://millbrae.patch.com/groups/politics-and-elections/p/in-bracing-moffett-field-for-climate-impacts-nasa-off292e1fc8d1*, accessed on December 8, 2013.

Shakesby, R.A., and S.H. Doerr. 2006. Wildfire as a hydrological and geomorphological agent. *Earth-Science Reviews* 74(3–4):269–307.

Sheffield, J., and E.F. Wood. 2008. Projected changes in drought occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations. *Climate Dynamics* 31(1): 79–105.

Shulski, M., and G. Wendler. 2007. *The climate of Alaska*. Fairbanks, AK: University of Alaska Press. As cited in R. Bronen reference above.

Siceloff, B. 2012. Sandy damage will keep Outer Banks bridge, highway closed for weeks. *NewsObserver.com*, November 1. Online at *www.newsobserver.com/2012/11/01/2452756/sandy-damage-will-keep-outer-banks.html*, accessed on October 9, 2013.

Slade, D. 2013.Charleston plans to complete major projects to address downtown flooding by 2020. *Post and Courier*, June 20. Online at *www.postandcourier.com/article/20130620/PC16/130629921*, accessed on October 15, 2013.

South Carolina Department of Natural Resources. No date. South Carolina climate. Online at *www.dnr.sc.gov/climate/sco/ClimateData/cli_sc_climate.php*, accessed on October 14, 2013.

South Carolina Department of Parks, Recreation, & Tourism. 2013. Discover South Carolina: The Old Exchange & Provost Dungeon. Online at *www.discoversouthcarolina.com/products/339.aspx*, accessed on October 14, 2013.

Southeast Florida Regional Compact Climate Change Technical Ad Hoc Work Group. 2011. A unified sea level rise projection for Southeast Florida. Online at *www.ces.fau.edu/files/projects/climate_change/SE_Florida_RegionalCompact_SeaLevelRise_April2011.pdf*, accessed on February 2, 2014.

Southwest Fire Consortium. No Date. Las Conchas fire fact sheet. Online *at http://swfireconsortium.org/wp-content/uploads/2012/11/Las-Conchas-Factsheet_bsw.pdf*, accessed on February 13, 2014.

Spoleto Festival USA. 2013. About the Spoleto Festival. Online at *http://spoletousa.org/*, accessed on October 14, 2013.

St. Augustine, Ponte Vedra & The Beaches, Florida Visitors and Conventions Bureau. 2004. Tourism and Economic Impact Research.

Stefanov, W., and K. Lulla. 2012. Climate change adaptation science activities at NASA Johnson Space Center. Paper for workgroup meeting, July 18-19, Houston, TX. Online at *http://nix.nasa.gov/search.jsp?R=20120015947&qs=N%3D4294950110%2B4294948758*, accessed on December 8, 2013.

Stewart, I.T., D.R. Cayan, and M.D. Dettinger. 2005. Changes towards earlier streamflow timing across western North America. *Journal of Climate* 18:1136–1155.

Stofan, E.R., C. Elachi, J.I. Lunine, R.D. Lorenz, B. Stiles, K.L. Mitchell, S. Ostro, L. Soderblom, C. Wood, H. Zebker, S. Wall, M. Janssen, R. Kirk, R. Lopes, F. Paganelli, J. Radebaugh, L.Wye, Y. Anderson, M. Allison, R. Boehmer, P. Callahan, P. Encrenaz, E. Flamini, G. Francescetti, Y. Gim, G. Hamilton, S. Hensley, W.T.K. Johnson, K. Kelleher, D. Muhleman, P. Paillou, G. Picardi, F. Posa, L. Roth, R. Seu, S. Shaffer, S. Vetrella, and R. West. 2007. The lakes of Titan. *Nature* 445:61–64. Online at *www.nature.com/nature/journal/v445/n7123/abs/nature05438*, accessed on February 16, 2014.

Tabb, K. 2013. Outer Banks moves toward unified shoreline plan. *North Beach Sun*, July 17. Online at *www.northbeachsun.com/outer-banks-moves-toward-unified-shoreline-plan*, accessed on April 6, 2014.

Tagger, B. 2013. New federal and state parks in Maryland commemorate life and legacy of Harriet Ross Tubman. April 6. Online at *http://march.rutgers.edu/2013/04/new-federal-and-state-parksin-maryland-commemoratelife-and-legacy-of-harriet-ross-tubman*, accessed on December 8, 2013.

Thompson, V.D., and J.E. Worth. 2011. Dwellers by the sea: Native American adaptations along the southern coasts of eastern North America. *Journal of Archaeological.* Research 19:51–101. Online at *www.academia.edu/375732/Dwellers_by_the_Sea_Native_American_Coastal_Adaptations_along_the_Southern_Coasts_of_Eastern_North_America._Journal_of_Archaeological_Research_19_51-101*, accessed on February 16, 2014.

Trenberth, K.E. 2011. Changes in precipitation with climate change. *Climate Research* 47:123–138.

Tuolumne County Chamber of Commerce. No date. Welcome to Tuolumne County, California. Online at *www.tcchamber.com*, accessed on February 6, 2014.

Turner, C. 2010. Managing effects of climate change at NASA's Wallops Flight Facility. Paper presented at the International Workshop on Environment and Energy: Global Collaboration in Sustainable Environmental and Alternative Energy Strategies, November 2–4, San Diego, CA. Online at *www.c3p.org/Workshop%202010/Thursday%20Nov%204/13-Carolyn_Turner_-_Managing_Effects_of_Climate_Change-WFFTurner.pdf,* accessed on December 8, 2013.

Unger, H.G. 2011. *American tempest: How the Boston Tea Party sparked a revolution*. Cambridge, MA: Da Capo Press.

United Farm Workers (UFW). 2012. Lawsuit says failed enforcement means California's farm workers face daily threat of heat illness and death. Press release, October 18. Online at *www.ufw.org/_board.php?mode=view&b_code=news_press&b_no=12798&page=1&field=&key=&n=877,* accessed on March 14, 2014.

U.S. Army. 2011. Norfolk District has unorthodox "farewell" gift for Fort Monroe. Online at *www.army.mil/article/54063/Norfolk_District_has_unorothodox__quot_farewell_quot__gift_for_Fort_Monroe/*, accessed on February 1, 2014.

U.S. Army Corps of Engineers (USACE). 2013. *Draft environmental assessment: Willoughby Spit and vicinity: Coastal storm damage reduction project, Norfolk, Virginia.* Online at *www.nao.usace.army.mil/Portals/31/docs/2WS-LRR-EA.pdf,* accessed on February 1, 2014.

U.S. Army Corps of Engineers (USACE). 2008a. *Addendum report: Flood reduction analysis for the United States Naval Academy.*

U.S. Army Corps of Engineers (USACE). 2008b. Historical vignette 111: Cape Hatteras Lighthouse. Online at *www.usace.army.mil/About/History/HistoricalVignettes/CivilEngineering/111CapeHatterasLighthouse.aspx*, accessed on April 6, 2014.

U.S. Army Corps of Engineers (USACE). 2006a. *Alaska village erosion technical assistance program: An examination of erosion issues in the communities of Bethel, Dillingham, Kaktovik, Kivalina, Newtok, Shishmaref, and Unalakleet.* Online at *http://housemajority.org/coms/cli/AVETA_Report.pdf,* accessed on February 2, 2014.

U.S. Army Corps of Engineers (USACE). 2006b. *Final flood damage reduction analysis for the United States Naval Academy.*

U.S. Department of the Interior. 2014. Reclamation announces initial 2014 Central Valley Project water supply allocation, February 21. Bureau of Reclamation Mid-Pacific Region, Sacramento, CA. Online at *www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=46045*, accessed on March 24, 2014.

U.S. Department of the Interior. 1969a. National register of historic places registration form: Annapolis, Maryland. Online at *http://architecturaltrust.org/~architec/wp-content/uploads/2013/06/Report_NR_Annapolis1.pdf,* accessed on November 6, 2013.

U.S. Department of the Interior. 1969b. National register of historic places registration form: U.S. Naval Academy.

U.S. Geological Survey (USGS). 2013. Federal wildland fire occurrence data. Online at *http://wildfire.cr.usgs.gov/firehistory/data.html*, accessed on May 4, 2013.

U.S. Government Accountability Office (GAO). 2013. *Climate change: Future federal adaptation efforts could better support local infrastructure decision makers.* Online at *www.gao.gov/assets/660/653741.pdf, accessed on December 18, 2013.*

U.S. Government Accountability Office (GAO). 2009. *Alaska native villages: Limited progress has been made on relocating villages threatened by flooding and erosion.* Report to congressional requesters. Online at *www.gao.gov/assets/300/290468.pdf,* accessed on February 2, 2014.

U.S. Government Accountability Office (GAO). 2003. *Alaska native villages: Most are affected by flooding and erosion but few qualify for federal assistance.* Report to congressional committees. Online at *www.gao.gov/assets/250/240810.pdf,* accessed on February 2, 2014.

University of Central Florida. 2011. Saving oyster habitat makes "heroes" of UCF biologist and team. Online at *https://today.ucf.edu/saving-oyster-habitat-makes-heroes-of-ucf-biologist-and-team/*, accessed on February 16, 2014.

Valine, K. 2014. It's finally all downhill as Dodge Ridge prepares to open, *Modesto Bee*. February 14. Online at *www.modbee.com/2014/02/10/3181971/its-finally-all-downhill-as-dodge.html*, accessed April 21, 2014.

Vitousek, S., M.M. Barbee, C.H. Fletcher, B.M. Richmond, and A.S. Genz. 2010. *Pu'ukohola Heiau National Historic Site and Kaloko-Honokōhau Historical Park, Big Island of Hawai'i: Coastal hazard analysis report*, Natural resource technical report NPS/NRPC/GRD/NRTR-2010/387. Fort Collins, CO: National Park Service.

Waterway Surveys & Engineering, Ltd., Virginia Institute of Marine Science, and URS Corporation. 2011. *Hampton beachfront and storm protection management plan*. Online at *http://web.vims.edu/physical/research/shoreline/docs/HamptonBeachfrontPlanFinal110415.pdf*, accessed on February 1, 2014.

Webster, P.J., G.J. Holland, J.A. Curry, H.-R. Chang. 2005. Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science* 309:1844–1846.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. *Science* 313:940–943.

Weyiouanna, T. 2014 Statement to Congress's Bicameral Task Force on Climate Change. January 14. Tony Weyiouanna is president of the board of the Shishmaref Native Corp. Online at *http://democrats.energycommerce.house.gov/sites/default/files/documents/Testimony-Tony-Weyiouanna-BTF-Forum-Shishmaref-Alaska-2014-1-14.pdf*, accessed on February 2, 2014.

The White House Office of the Press Secretary. 2012. Remarks by the President at the dedication of the César Chávez National Monument, Keene, CA. October 8. Online at *www.whitehouse.gov/the-press-office/2012/10/08/remarks-president-dedication-cesar-chavez-national-monument-keene-ca*, accessed on February 11, 2014.

Wilder, C.B. 1863. Excerpts from testimony of the Superintendent of Contrabands at Fortress Monroe, Virginia, before the American Freedmen's Inquiry Commission. Online *at www.freedmen.umd.edu/wilder.htm*, accessed on February 1, 2014.

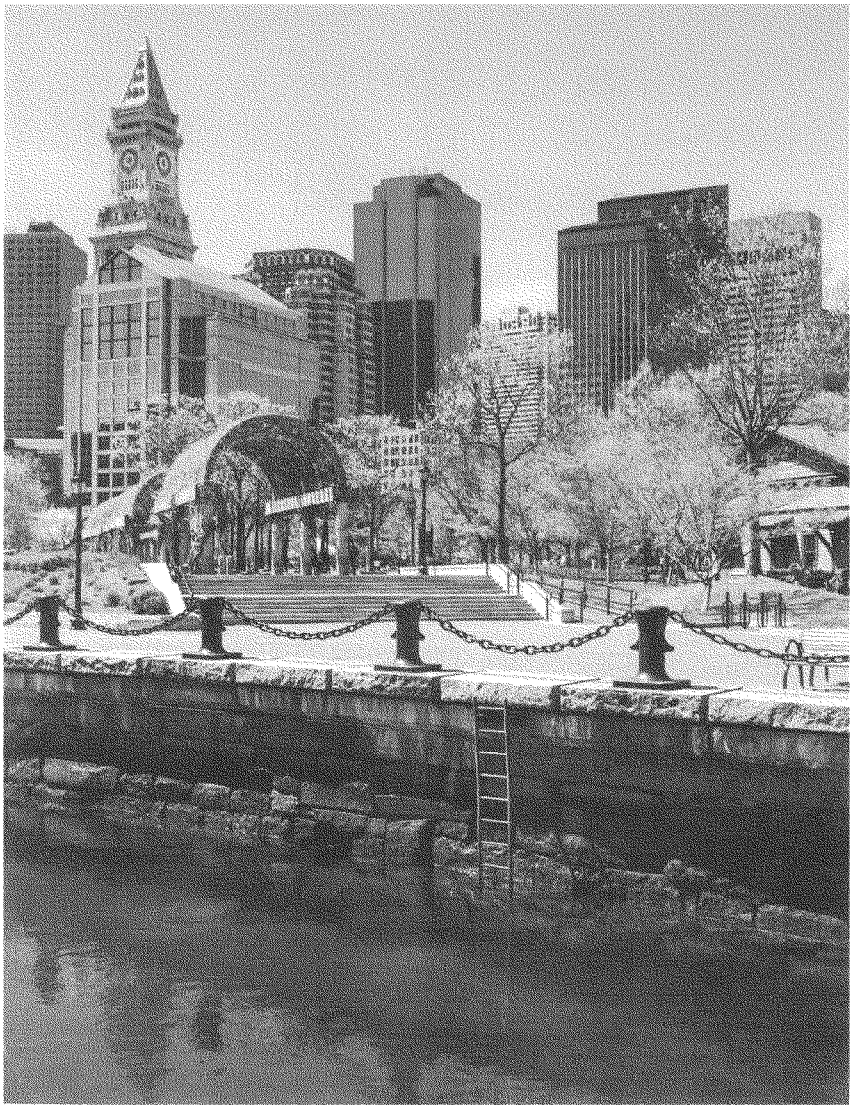
Wood, P. 2013. New, returning vendors poised to reopen Annapolis Market House. *Baltimore Sun*, June 17. Online at *http://articles.baltimoresun.com/2013-06-17/news/bs-md-ar-market-house-progress-0613-20130613_1_annapolis-market-house-new-vendors-yellowfin-seafood-oyster-bar*, accessed on March 21, 2014.

Woods, S.W., A. Birkas, and R. Ahl. 2007. Spatial variability of soil hydrophobicity after wildfires in Montana and Colorado. *Geomorphology* 86(3–4):465-479.

Wozniacka, G. 2012. California poverty: Three metro areas in Central Valley rank among the poorest in the nation. *Associated Press*. September 20. Online at *www.huffingtonpost.com/2012/09/20/california-poverty_n_1901642.html*, accessed on March 24, 2014.

(Right:) Boston's historic Long Wharf, which includes Christopher Columbus Waterfront Park, is at risk from rising seas and storm surge.[489]

©iStockphoto.com/Agnieszka Gaul



National Landmarks at Risk

How Rising Seas, Floods, and Wildfires Are Threatening the United States' Most Cherished Historic Sites

> ***The stories these sites tell symbolize values—such as patriotism, freedom, democracy, respect for ancestors, and admiration for the pioneering and entrepreneurial spirit—that unite all Americans.***

Many of the United States' iconic landmarks and heritage sites are at risk as never before. Sea level rise, coastal erosion, increased flooding, heavy rains, and more frequent large wildfires are damaging archaeological resources, historic buildings and cultural landscapes across the nation. From sea to rising sea, a remarkable number of the places where American history was made are already under threat from the impacts of climate change.

This report offers a selection of case studies that vividly illustrate an urgent problem. These examples represent many of the rich and diverse elements of the American experience. The stories were chosen because the science behind the risks they face is robust, and because together they shine a spotlight on the different kinds of climate impacts already affecting the United States' cultural heritage.

Given the scale of the problem and the cultural value of the places at risk, it is not enough merely to plan for change and expect to adapt. We must begin now to prepare our threatened landmarks to face worsening climate impacts; climate resilience must become a national priority and we must allocate the necessary resources. We must also work to minimize the risks by reducing the carbon emissions that cause climate change.

Union of Concerned Scientists

FIND A FULLY CITED VERSION OF THIS REPORT ONLINE: www.ucsusa.org/landmarksatrisk

The Union of Concerned Scientists puts rigorous, independent science to work to solve our planet's most pressing problems. Joining with citizens across the country, we combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe, and sustainable future.

NATIONAL HEADQUARTERS
Two Brattle Square
Cambridge, MA 02138-3780
Phone: (617) 547-5552
Fax: (617) 864-9405

WASHINGTON, DC, OFFICE
1825 K St. NW, Suite 800
Washington, DC 20006-1232
Phone: (202) 223-6133
Fax: (202) 223-6162

WEST COAST OFFICE
2397 Shattuck Ave., Suite 203
Berkeley, CA 94704-1567
Phone: (510) 843-1872
Fax: (510) 843-3785

MIDWEST OFFICE
One N. LaSalle St., Suite 1904
Chicago, IL 60602-4064
Phone: (312) 578-1750
Fax: (312) 578-1751

WEB: www.ucsusa.org